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PROCEEDINGS

of the

Indiana Academy *of* Science

Founded December 29, 1885

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VOLUME 57

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P. D. EDWARDS, EDITOR

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Spring Meeting
CORYDON, INDIANA
May 9 and 10, 1947

Sixty-Third Annual Meeting
BALL STATE TEACHERS COLLEGE
October 16, 17, and 18, 1947

Copies of the Proceedings may be purchased through the State Library, Indianapolis, Indiana, at $3.00 per volume. All items sent in exchange for the Proceedings and all communications to officers of the Academy, when their names and addresses are not known, should also be sent to the State Library.

Reprints of certain parts of recent volumes of the Proceedings are available for distribution as follows: copies of the constitution and by-laws (Vol. 44), and complete membership list (Vol. 56), may be secured by members elected subsequent to the publication of those volumes; copies of the codified list of duties of officers (Vol. 48) may be secured by officers, divisional chairmen, and chairmen of committees; and copies of the necrology can be supplied to relatives and friends of the deceased members. Inquiries concerning these reprints should be addressed to the Secretary of the Academy, Dr. O. B. Christy, Ball State Teachers College, Muncie, Indiana.

Reprints of technical papers in recent volumes can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

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OFFICERS AND COMMITTEES FOR 1947

OFFICERS

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Vice-President A. R. BECHTEL, Wabash College.
Secretary, WINONA H. WELCH, DePauw University.
Treasurer, W. P. MORGAN, Indiana Central College.
Editor, P. D. EDWARDS, Ball State Teachers College.
Press Secretaries, C. M. PALMER, Butler University, and W. E. EDINGTON, DePauw University.
Trustees of Academy Foundation: J. S. WRIGHT, Eli Lilly & Company, (term expires 1948), chairman; F. B. WADE, Shortridge High School, (term expires 1947).
Committee for Bonding of Trustees: R. C. FRIESNER, Butler University, chairman; SCOTT MCCOY, Arsenal Technical High School.
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Bacteriology, S. E. HARTSELL, Purdue University.
Botany, NOE HIGINBOTHAM, University of Notre Dame.
Chemistry, ALVIN STRICKLER, Evansville College.
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Physics, B. A. HOWLETT, Rose Polytechnic Institute.
Psychology, ALMA LONG, Purdue University.
Zoology, A. E. REYNOLDS, DePauw University.

EXECUTIVE COMMITTEE

(Past Presidents, Officers, Divisional Chairmen, and Chairmen of Standing Committees)

A. R. Bechtel, C. A. Behrens, O. B. Christy, W. A. Cogshall, E. R. Cumings, J. J. Davis, C. C. Deam, E. F. Degering, C. F. Deiss, W. E. Edington, P. D. Edwards, H. E. Enders, R. C. Friesner, W. G. Gingery, S. E. Hartsell, Noe Higinbotham, B. A. Howlett, Theodor Just, Eli Lilly, Alma Long, J. F. Mackell, E. G. Mahin, C. A. Malott, M. S. Markle, K. S.

Means, M. G. Mellon, H. H. Michaud, W. P. Morgan, C. M. Palmer, F. Payne, J. C. Polley, R. R. Ramsey, A. E. Reynolds, W. E. Ricker, B. H. Smith, Alvin Strickler, J. E. Switzer, Erminie Voegelin, F. B. Wade, F. N. Wallace, Paul Weatherwax, Winona H. Welch, J. S. Wright, T. G. Yuncker.

BUDGET COMMITTEE

(President, Secretary, Treasurer, Editor, and Chairmen of Committees on Fifty-Year Index, Junior Academy, Library, Program, and Relation of Academy to State)

J. F. Mackell, O. B. Christy, P. D. Edwards, R. C. Friesner, W. G. Gingery, H. H. Michaud, W. P. Morgan, F. N. Wallace, Winona H. Welch.

STANDING COMMITTEES

(Appointed by the President, Chairman of each committee named first)

Auditing: K. S. Means, E. S. Martin, J. E. Potzger.

Biological Survey: W. E. Ricker, W. P. Allyn, A. R. Bechtel, J. J. Davis, H. O. Deay, H. H. Michaud, B. E. Montgomery, C. M. Palmer, J. E. Potzger, Winona H. Welch.

Fifty-Year Index: R. C. Friesner, Nellie M. Coats, W. P. Morgan, F. N. Wallace, Paul Weatherwax.

Invitations: B. H. Smith, R. B. Abbott, Edward Kintner, S. S. Visher.

Junior Academy: H. H. Michaud, W. P. Allyn, O. B. Christy, F. R. Elliott, M. S. Markle, C. L. Porter, F. B. Wade, T. G. Yuncker.

Library: W. G. Gingery, Nellie M. Coats, R. C. Friesner.

Membership: J. E. Switzer, J. J. Davis, G. F. Hennion, G. D. Koch, R. Earl Martin, W. E. Martin, J. E. Potzger, J. S. Wright.

Necrologist: W. E. Edington.

Nominations: M. S. Markle, W. E. Edington, R. R. Ramsey.

Program: O. B. Christy, G. Alexander, R. Cooper, D. Hartley, Floy Hurlbut, R. McCormick, D. Miller, C. Peirce, R. Shelley.

Publication of Proceedings: P. D. Edwards, R. C. Corley, Paul Weatherwax.

Relation of Academy to State: F. N. Wallace, E. Y. Guernsey, H. J. Reed, J. S. Wright.

Representative on Council of A.A.A.S.: E. F. Degering.

Resolutions: W. E. Edington, S. E. Elliott, M. E. Hufford.

MINUTES OF THE SPRING MEETING

CORYDON

MAY 9, 10, 1947

President Mackell called the Executive Committee meeting to order at 4:30 p.m., May 9, in the auditorium of the Methodist church.

W. P. Morgan presented the final report of the treasurer for the year 1946. Accepted.

P. D. Edwards announced that galley proof for 1946 Proceedings had been returned to the printer. The State Legislature has granted $2500 annually for aid in printing the Proceedings during the next two years.

C. M. Palmer stated that Butler University Publicity Department and the various presses had co-operated with him in the publicity concerning the Corydon meeting. He recommends the use of the printed programs of the Academy in giving the information to the various reporters and editors.

Ray C. Friesner hopes to send the 50-year index to the printer about the middle of June. The State Legislature appropriated $2500 for the publication of the index.

Nellie M. Coats, Academy Librarian, prepared the following report:

There has been a noticeable increase in the use of materials in the Academy's library particularly by other special libraries in the state. Requests have come also from such libraries as those of Northwestern University and of the U. S. Department of Agriculture. A file of the Proceedings was presented to the new Indiana Water Supply Commission upon its request. Scarce volumes of the Proceedings making such gifts possible were returned to the Academy recently by St. Mary of the Woods College and the Michigan State Department of Health. Eleven boxes of duplicate scientific periodicals accumulated by the Academy library were presented to the American Book Center at the Library of Congress for distribution to war devastated institutions. Twenty-three new titles were added to the list of periodicals currently received. These included such publications as Pacific Science (University of Hawaii); New Zealand Museum Records in Ethnology; Instituto Italiano di Idrobiologia Memorie; Indian Academy of Science Proceedings; Los Angeles County Museum Quarterly; South Africa Government Metallurgical Laboratory Memoirs. The Library supplied material to an Indianapolis Star reporter for an article about the Academy and a volume of the Proceedings was included in a display of books at L. S. Ayres recently. Many school children visited the State Library during the legislative session and to each group something was said about the Junior Academy.

J. E. Switzer presented 22 applications for membership. Elected.

O. B. Christy reported 126 dinner reservations for the evening program.

E. F. Degering, Indiana's representative on A.A.A.S. Council, announced that H. H. Michaud was elected president of the Academy

Conference at the Boston meeting last December. H. H. Michaud reported that extraordinary interest was expressed at the Academy Conference in the Junior Academy movement. A mimeographed copy of the Conference minutes was presented to the secretary for the Academy files.

It was recommended that H. H. Michaud, Chairman of Indiana Junior Academy of Science, attempt to bring into active membership all clubs which have been organized in Indiana and to present the list of active clubs at the fall meeting.

Ray C. Friesner presented the objection of many botanists concerning the present state flower, the Zinnia, and recommended that the president appoint a committee for the purpose of selecting a new state flower. Motion was made and carried.

C. M. Palmer, Press Secretary, presented his resignation due to his anticipated absence from the state at the time of the fall meeting. It was accepted with sincere regret. A motion was made and carried that the nominating committee appoint a Press Secretary to complete the Palmer unexpired term.

President Mackell read a letter from a Fellow of the Academy with proposals concerning two annual $25.00 prizes which he wishes to give beginning in 1947 for the two best papers published in the Proceedings during the preceding five years. The details of procedure planned by the anonymous donor were read. The gifts and the proposals were accepted with appreciation and the editor, P. D. Edwards, was made chairman of the committee to make the 1947 selections.

The Executive Committee expressed the need of broader publicity concerning the available A.A.A.S. Academy research grants.

Meeting adjourned at 5:45.

Following the dinner at 6:30 an address of welcome was given by Judge S. Morris Wilson, a talk on the local history of Corydon and vicinity was given by Fred Griffin, and short talks on the Geology and Botany of the area were given by Preston McGrain and Ray C. Friesner.

On Saturday morning, May 10, three field trips were organized. These trips and the leaders follow:

Bird hike led by Howard Michaud.

Botanical trip led by Ray Friesner.

Geology trip led by Preston McGrain.

MINUTES OF THE EXECUTIVE COMMITTEE

MUNCIE, OCTOBER 16, 1947

The Executive Committee was called to order by President Mackell at 8 p.m., in Committee Room, Hotel Roberts. The minutes of the Corydon meeting were read and approved. The reports of officers and committee representatives were presented and accepted as follows:

Academy Trustee. Report of John S. Wright and Frank B. Wade, Trustees of the Foundation Fund, Indiana Academy of Science for the year 1946-1947.

Balance from the previous year	$1.07
Total Receipts	184.50
Total	$185.57
Expenditures—Union Trust Co. Fee 5% on $184.50	9.23
Cash balance at Union Trust Company	$176.34

Assets in the Fund as of September 30, 1947

Five $1,000 U. S. Savings Bonds Series "D", Cost	$3,750.00
$6,900 U. S. Treasury Bonds Series "G", Cost	6,900.00
Six shares Standard Oil of Indiana Common Stock, par	150.00
Total at par or cost	$10,800.00

Treasurer. W. P. Morgan presented a tentative financial report for the period from January 1 to October 1, 1947. His final report, approved by the Auditing Committee at the end of the year, follows:

Receipts

Balance on hand January 1, 1947	$3,272.85	
Dues and initiation fees	1,074.00	
Refund for research from A.A.A.S.	200.00	
Designated gift	200.00	
Gift designated for author awards (1947)	50.00	
Gift designated for author awards (1948)	50.00	
Author's reprint Vol. No. 54	2.70	
Author's reprints Vol. No. 55	398.10	
		$5,247.65

Disbursements

1—Program Committee	$ 243.78
2—Editor Vol. No. 56	200.00
3—Expenses of Secretary	157.99
4—Expenses of Treasurer	77.50
5—Mailing Proceedings	54.18
6—Stationery	84.50
7—Mary Fritsche (50 yr. index)	130.50
8—Doris Colligan (50 yr. index)	15.75
9—Reprints Vol. No. 55	541.34
10—Jr. Academy expenses	16.91
11—Publications for Library	6.69

12—Author award 1947 R. C. Friesner	25.00
13—Author award 1947 J. P. Scott	25.00
14—Research grant A. E. Reynolds	37.50
15—Research grant W. E. Thrun	37.50
16—Research grant Robt. Drummond	25.00
17—Surety Bond (3 yr. term)	62.50
18—Eunice Henley (50 yr. index)	300.00
19—Refund to Section Chairman	4.00
20—Research grant J. R. Potzger	125.00
21—Reprints Vol. No. 56	746.25
22—Returned check	1.00
	$2,917.89
*Balance on hand	2,329.76
	$5,247.65

* Balance includes $1,000.00 in gifts designated for the completion of work on the fifty-year index and the preparation for publication of the "Indiana Men of Science."

(Signed) W. P. MORGAN, *Treasurer*
(Signed) KARL S. MEANS
S. E. ELLIOTT, *Auditors*

Auditing Committee. Accounts of the Academy Trustees and Treasurer have been carefully checked and found in good order.

Bonding Committee. R. C. Friesner reported that the Academy carries with the Hartford Accident and Indemnity Co. bonds in the amount of $2000.00 for the Treasurer and $5000.00 each for the Trustees. These are renewable annually at a total cost of $25.00. Expiration date is November 18. The Executive Committee authorized the continuance of the bonds, and if permissable, to pay the cost of the bonds triennially instead of annually and at a saving to the Academy.

Editor and Publication of Proceedings. P. D. Edwards reported that the presswork on volume 56 has been completed and that the 1600 volumes are now at the bindery. The printing of the 10,750 reprints has just been finished.

Research Grant Committee. T. G. Yuncker reported that only one request for a grant had been received during the year, that of J. E. Potzger for $50.00 to partially cover expenses in connection with a problem in the study of pollen in bogs in Quebec, Canada; that W. E. Martin, who had a grant for $75.00, had left the state and the unpaid half of his grant had reverted to the treasury; that the final report of Kenneth Wagner had been received and his grant completed; that grants not used by the Academy during the two-year period immediately following the making of same by A.A.A.S. will revert to A.A.A.S.; and that approximately $300.00 are now available, awaiting applications for same.

Biological Survey. W. E. Ricker submitted the following report:

Since the last report of this committee, given in 1944, faunal and floral work in Indiana has made considerable progress in spite of the handicap of the diversion of national energy and manpower to war needs.

Algae and Lower Plants: William A. Daily has published two papers on algae and one on Myxomycetes. Fay Kenoyer Daily has a preliminary report on Indiana Characeae.

Bryophytes: Winona Welch is continuing her collecting and identifying of these forms as well as collecting Myxomycetes and lichens.

Vascular Plants: The State Flora Committee and others have continued work on the distribution of vascular plants. Two recent revisions including Indiana material are of *Asclepias* (milkweeds) and *Liatris.*

Ecological and General Floristic Surveys of Limited Regions: A considerable number of papers have appeared in these fields, largely in the Butler University Botanical Studies, by J. E. Potzger, Ray C. Friesner, C. O. Keller, Mordie B. Lee, and Howard L. Cook.

Insects: In two recent papers read before the Academy, B. Elwood Montgomery has reported on the spatial and seasonal distribution of *Agrionidae* and has reviewed a century of odonatology in Indiana. Donald C. Scott has published a list of Odonata from the Tippecanoe River State Park.

Indiana lists have been recently published for Thysanoptera by C. C. Blickenstoff, and for Culicidae (mosquitoes) by John W. Hart. Work in progress or near completion includes a survey of fleas from Indiana mammals (Frank Skinner), a study of Mecoptera (John Kingsolver), of Aphididae (Virgil Knopp), of various Hemiptera and Homoptera (Howard O. Deay), and of miscellaneous insects from light traps (Donald Schnider).

Attention should be called to H. H. Ross's recent monograph on the "Mosquitoes of Illinois", which will be of great value in Indiana.

Mollusks: Goodrich and Van der Schalie have now published their synopsis of the Mollusca of Indiana which brings the work of Call and Blatchley into modern form as well as adding new records.

Fishes: Shelby D. Gerking has published the "Distribution of Indiana Fishes" giving the results of his four years of collecting. More recently he has discussed the use of post-glacial drainage connections in the invasion of Indiana by various species.

Birds and Mammals: New Indiana bird records appear from time to time in the various ornithological journals. The quarterly reports of the Pitman-Robertson Wildlife Research Project of the Division of Fish and Game contain much information on game birds and mammals, and also on other birds and mammals, especially fur-bearers.

The detailed bibliographic citation of the works referred to above have been added to the file already in the Committee's hands.

The Committee recommends that some one actively working with birds (and possibly also mammals) be added to its membership in order to facilitate its work.

Fifty-Year Index Committee. R. C. Friesner presented the following detailed report.

Manuscript for the 50-year index is in the hands of the State Printing Board. The Committee makes the following recommendations:

1. The volume will be 6 x 9 (same size as the Proceedings), two columns per page; 8-point type, bound in cloth of different color from the Proceedings. Estimated number of pages, 350.
2. Number of copies to be printed: 2,000.
3. Distribution:
   a. Public and college libraries and all exchanges free.

b. Members of five years standing, or any who will pay dues in advance sufficient to make a five-year membership, free upon request. Return announcement card to be sent each member at the first regular Academy mailing following date of issue of the Index.

One copy only to the member on this basis.

c. Sale copies available to all not included in the above. Sale price to be $3.00 (same as the Proceedings).

4. Financing: The 2,000 copies are expected to cost approximately $1,000 more than has been appropriated by the State.

The Committee will endeavor to secure these additional funds.

Library Committee. W. G. Gingery presented a report prepared by Nellie M. Coats, Academy Librarian.

Since the May report 22 new serial titles have been added, a total of 45 for the year, including such publications as the University of Sydney, Department of Zoology Monographs; University of Arizona, Laboratory of Tree-ring Research Bulletins, the New Zealand Dominion Museum Records in Zoology and Records in Entomology.

Certain early files have been filled in by further gifts from issuing agencies such as the Swedish entomological society.

Some issues of the New York Academy of Science Annals and the Kansas Academy of Science Transactions, long since out of print, were purchased from dealers.

Gaps of the last few years in foreign titles were filled by materials held for American libraries during the war.

Volumes of the I. A. S. Proceedings held here during this period were distributed to 35 agencies which had been inaccessible. Volumes destroyed by war were replaced for nine agencies in Belgium, England, France, Holland, and Norway.

In addition to the file of the Proceedings supplied the Indiana Water Supply Commission, a file was completed for the Indiana Geological Survey's Bloomington office.

As a delegate, representing the State Library, your librarian attended the national convention of the Special Libraries Association at Chicago and visited various scientific libraries there, with, it is hoped, some profit to the academy.

Press Secretary. C. M. Palmer is in India for a period of two years. W. E. Edington has substituted as Press Secretary for this meeting, which has received publicity in numerous papers throughout the state.

Membership. J. E. Switzer presented the following report on Interests and Geographic Distribution of Academy Membership.

The chairman of the Membership Committee of the Academy of Science, in an effort to find a more efficient method of canvassing the educational institutions of the state for new members, made a study of the distribution of the membership of the academy as listed at the close of the last calendar year. It was soon discovered that the members could not be listed by institutions and departments, because too many gave only their home addresses with no reference to the institution, if any, in which they were employed. Therefore, the only groupings that seemed feasible were on the basis of the Sections of the Academy in which they listed their major interests, and their geographic distribution in cities. A graph to show the facts in regard to these two items was constructed and composes a part of this report to the Academy.

Distribution in Academic Interests. Many persons naturally have more than one subject of major interest. In construction of the graph, each interest indicated by a person was counted, hence the total number of persons represented in this part of the chart is much greater than the actual membership. Botany and Biology, grouped together in the chart, stand out as greatly in the lead of the others, 320 members having expressed their interest in them. Zoology ranks next with 253 persons naming it as a major interest. Chemistry ranks third with 222, Physics fourth with 148, and Geology-Geography fifth with 118. These five Sections comprise 80% of the total preferences expressed. The remaining four sections contain only 20%. Apparently those interested in the Section of Entomology recorded their interest subject as Zoology. The sections of Anthropology and Bacteriology are relatively new sections but seem to be making a healthy growth. The addition of 134 new members this year will probably make changes in the relative ratings of the sections.

Geographic Distribution of Members. In the geographic distribution of members, the chart indicates the outstanding importance of Indianapolis. This reflects the influences of Butler University, Indiana Central College, the I. U. and Purdue University extension divisions, Eli Lilly Laboratories, the Department of Conservation, and others. Indianapolis, plus Lafayette and Bloomington contain 42% of the total membership. The size of the two state universities account for the importance of the two latter cities. Fifteen other towns, with as many colleges, in the state are given as the home addresses of 22% of other members. Another 13%, without indicating any connection with any college, give their addresses in other towns of the state. A striking fact is that more than 23% have addresses outside the state of Indiana. These addresses reach from Florida to Minnesota, and from California to Maine. It suggests that members of the Academy who leave the state consider their membership in the Academy of sufficient importance to maintain it, though they may not be able to attend any of its sessions.

Junior Academy of Science. H. H. Michaud presented the following report:

The fourteenth annual meeting of the Indiana Junior Academy of Science was held Saturday, October 19, 1946, in the Sycamore Theatre of the Laboratory School, Indiana State Teachers College, Terre Haute.

Approximately one hundred members, sponsors, and friends attended the meeting. Ten clubs and their sponsors were represented.

During the past year more than two hundred science teachers have been informed by mail about the activities of the Junior Academy. On the basis of responses received during the past two years, there are at present about 20 Junior Academy Clubs that are more or less actively engaged in science club activities.

Last year the Budget Committee of the Academy voted to allow $50.00 to the Junior Academy for operating expenses. The amount spent to date is $16.91. This does not include this year's expenses for the annual meeting which should not exceed $15.00. These expenditures included mailing of mimeographed materials, announcements of the fall meeting, and paper materials for a News Letter sent to active and prospective clubs last spring. If the State Sponsor had more time to devote to promotion it would not be difficult to use all of the budget allotment. It is hoped that the Academy will see fit to continue the funds for next year.

There are a few hopeful signs that the Junior Academy clubs will increase in number during the next few years. Five or six requests for applications for new clubs have been received during the past few months.

The status of the Junior Academy was a special topic of discussion at the Academy Conference held in Boston last December during the meeting

of the American Association for the Advancement of Science. Because there was such intense interest in the subject, the topic will be included again at the meeting next December in Chicago. Moreover, a Junior Scientists Assembly, sponsored jointly by the AAAS and the National Science Teachers Association, was instituted last year for high school students and was so successful that it will be repeated again this year.

Scientists are becoming more concerned with the effectiveness of science teaching at all the school levels. It is recognized that science talent must be found and stimulated through both interest, and financial aid if future scientists are to be developed. Seventy-six Indiana students completed the science examination of the Westinghouse Science Search conducted by Science Clubs of America last spring in competition with more than three thousand high school students of the nation. There were no Indiana winners, but two received honorable mention. Forty national winners are selected each year and a full subsistence, four year scholarship of $2,400.00 each is given to the two top ranking contestants.

Reference is made to this Science Talent Search because it provides the mechanism for finding future scientists in our own state. Steps are under way at Purdue for developing a plan to grant full subsistence scholarships to students who show scientific promise. In many cases industry and local community groups might be called upon to lend financial support. It is hoped that this plan will set a pattern for other state colleges and universities to do the same. The results of the Westinghouse examination are available to our state. However, it does not mean that the state cannot conduct its own science talent search. The important thing is that such a plan when put into operation will do much toward stimulating more effective teaching of science and it will also promote greater activity among Junior Academy clubs. It should be an obligation of the Senior Academy to support any worthwhile plan to develop the best possible scientists in Indiana.

The Executive Committee voted to continue the appropriation, not to exceed $50.00, to aid Dr. Michaud in advancing the work of the Junior Academy.

Relation of Academy to State. F. N. Wallace stated that the State Legislature has appropriated $2500.00 for aid in printing the Proceedings and $2500.00 for aid in printing the 50-year Index.

Relation of Academy to A.A.A.S. E. F. Degering reported that 30 attended the Academy Conference in Boston in 1946 and that a good program has been prepared for the 1947 meeting in Chicago. He urged all Academy members to attend the December, 1947, meetings of A.A.A.S.

Nominations Committee. President Mackell announced that the committee consisted of M. S. Markel, chairman, W. E. Edington, and R. R. Ramsey. No report was made by the committee due to the absence of one of the members.

Old Business. W. E. Edington presented a detailed progress report for the Committee on History of Science in Indiana or Indiana Men of Science. President Mackell announced the membership of the State Flower Committee to be R. C. Friesner, chairman, Nellie M. Coats, C. C. Deam, D. DenUyl, B. H. Smith, and F. N. Wallace.

New Business. F. B. Wade was elected to succeed himself as Trustee of Academy Foundation, (term expires in 1951). R. C. Friesner and

Scott McCoy were elected to succeed themselves as committee on Bonding of Trustees, (term expires in 1948). E. G. Mahin was elected to succeed himself on Research Grant Committee, (term expires in 1952). The application of the Entomologists for a Section or Division in the Indiana Academy was granted. It was voted to invite the Civil, Electrical, Chemical, and Mechanical Engineers to organize a Section in the Academy, the invitation to be presented through Dean A. A. Potter, School of Engineering, Purdue University. A letter was read from A.A.A.S. suggesting that representatives on the Council be elected for a term of office not less than two years, and informing the Academy that only Fellows may serve on the Council of the Association.

The following resolution was read by J. S. Wright and adopted by the committee.

WHEREAS the Secretary, Treasurer, Press-Secretary, Editor and Librarian serve the Academy more or less continuously throughout the year at a sacrifice of leisure; and

WHEREAS they receive no compensation for arduous work that can be done only by those with special experience and training; and

WHEREAS it is incumbent on these officers to attend all meetings of the Academy in the performance of their official duties: Therefore be it

RESOLVED, That in addition to the present allowance for postage, stationery and other expenses involved in the work of their respective offices, the Academy as a token of appreciation allow the Secretary, Treasurer, Press-Secretary, Editor and Librarian each an amount not exceeding twenty (20) dollars per year to help defray personal expenses incurred in attending the annual winter meeting and the spring field meeting; furthermore be it

RESOLVED, That the treasurer be authorized to pay such allowances out of the Academy treasury on vouchers presented in compliance with the procedure provided for the payment of accounts owed by the Academy.

The meeting adjourned at 10 p.m.

MINUTES OF THE GENERAL SESSION

BALL STATE, OCTOBER 17, 1947

Dr. J. R. Emens, President of Ball State Teachers college, delivered the Address of Welcome. President Mackell responded in behalf of the Academy.

W. E. Edington presented the Necrology.

Minutes of the Executive Committee meeting of October 16, 1947, were read by the Secretary and approved by the Academy.

A motion was made and accepted that because of the inability of the Nominations Committee to meet before the Executive Committee meeting to nominate Fellows of the Academy at the October 16 meeting that the rule be suspended at this meeting of the Academy and that nominations for Fellows and their election occur at the dinner meeting.

Following the annual dinner in the Burris School Recreation Room, J. E. Switzer presented 115 applications for membership. The Secretary was instructed to cast an unanimous ballot for the 115 applicants. Total for 1947 is 137 new members.

M. S. Markle read the nominations of the committee as follows: *Fellows*, J. H. Hoskins, Scott McCoy, R. Earl Martin, H. H. Michaud, and C. F. Voegelin; *President*, Winona H. Welch, DePauw University; *Vice-President*, Mason E. Hufford, Indiana University; *Secretary*, O. B. Christy, Ball State Teachers College; *Assistant Secretary*, Donald E. Miller, Ball State Teachers College; *Treasurer*, W. P. Morgan, Indiana Central College; *Editor*, P. D. Edwards, Ball State Teachers College; and *Press Secretary*, William A. Daily, Butler University.

The Divisional Chairmen elected in the sectional meetings for 1948 were announced as follows: *Anthropology*, Arthur B. Carr, Indianapolis; *Bacteriology*, M. S. A. Campbell, Indianapolis; *Botany*, H. J. Brodie, Indiana University; *Chemistry*, E. S. Gantz, Purdue University; *Entomology*, W. P. Allyn, Indiana State Teachers College; *Geology and Geography*, Floy Hurlbut, Ball State Teachers College; *History of Science*, S. S. Visher, Indiana University; *Mathematics*, L. H. Whitcraft, Ball State Teachers College; *Physics*, J. C. Hendricks, Franklin; *Psychology*, D. G. Ellson, Indiana University; and *Zoology*, J. W. Baechle, St. Joseph's College.

P. D. Edwards, Chairman of the Committee on Prize Awards, read the following report:

Last February a Fellow of the Academy wrote President Mackell a letter expressing his desire to give anonymously two prizes each year for distinguished papers published in the *Proceedings*. By the terms of the gift, the President and Editor choose each year the two fields in which the award is made. The final selection is made by a committee consisting of those who during the preceding five years have served as President or Editor of

the Academy and those who during the same period have served as Chairmen of the two sections selected.

Your President and Editor have selected for this year fields to honor the first two men who served as Presidents of the Academy: David Starr Jordan and John B. Coulter. The fields are Vertebrate Zoology and Botany.

Your committee has made the following selections to receive the awards in 1947:

The Jordan award is made to Dr. J. Paul Scott, formerly Professor of Zoology at Wabash College and now Director of Behavior Studies, Hamilton Station, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine. Dr. Scott's paper in volume 53 appearing under the title "Social behavior, range, and territoriality in domestic mice" is significant in marking the beginning of a series of important investigations in behavior studies of vertebrates.

The John B. Coulter award is made to Dr. Ray C. Friesner, Dean of the School of Science of Butler University, for his work as Secretary of the State Flora Committee, whose report is an annual feature of the *Proceedings,* and for his researches on tree growth.

B. H. Smith, chairman of the Committee on Invitations, announced that the invitation from Indiana University, Bloomington, had been accepted for the 1948 Fall Meeting of the Academy.

W. E. Edington, chairman of the Resolutions Committee, and in behalf of the Academy, read the following Resolution:

The Indiana Academy of Science, assembled in its sixty-third annual meeting, expresses its appreciation and thanks to the faculty and students of Ball State Teachers College for their hospitality, and in particular to President Emens for his words of welcome, to Choir Director, F. Lemuel Anderson, for the music of the A Capella Choir, and to Professor O. B. Christy and his committee of faculty and students who have made this meeting pleasant and successful.

With regard to "Save the Shades", W. E. Edington read the following resolution:

Whereas: The Indiana Academy of Science, from its very inception, has exerted active leadership in State conservation projects, in such fields as conservation of natural resources, bird protection, stream pollution, weed eradication, and forest preservation, and

Whereas: Such great leaders in the Academy, past and present, such as David Starr Jordan, Amos W. Butler, Willis S. Blatchley, Stanley Coulter, Richard Lieber, Father Nieuwland, Marcus W. Lyon, Arthur L. Foley, Charles C. Deam, John S. Wright, and many others, have been alert to the State conservation needs and have tirelessly and unselfishly worked for the preservation and development of the State's resources in lakes, parks and forests, and

Whereas: There is a distinct need of prompt and active coöperation of all possible agencies to secure and preserve The Shades, at Waveland, for the future enjoyment of ourselves and posterity,

Therefore be it resolved: That the Indiana Academy of Science recommends to its membership their active participation in the securing of funds and their influence in publicizing the need and promoting the coöperation of all civic and State groups, civic clubs, and other organizations and individuals, in the addition of The Shades to the State Park System.

And be it further resolved: That the Academy urges Governor Gates and the State Legislature to use all means to secure The Shades and to develop a long range program that will provide for similar future acquisitions, and

Be it further resolved: That copies of this Resolution be sent to Governor Gates and the Director of the State Conservation Department.

Vice-President Bechtel introduced President Mackell who delivered a challenging address on "Graduate Degrees for College Science Teachers."

The 63rd annual meeting of the Indiana Academy of Science, with a general attendance of 350 and a dinner attendance of 136, was adjourned.

WINONA H. WELCH, *Secretary.*

TAXONOMISTS MEETING

R. C. Friesner, Butler University, Chairman

The Plant Taxonomists held their meeting on Saturday morning at Ball State Teachers College. Naomi Mullendore was elected chairman for 1948.

INDIANA JUNIOR ACADEMY OF SCIENCE

Officers for 1947:

President: ROBERT REINHOLD, Junior Izaak Walton Club, Central High School, South Bend.

Vice-President: MARILYN LEECH, Science Club, William A. Wirt High School, Gary.

Secretary: RAE SAFERIGHT, Science Club, George Washington High School, Indianapolis.

Members of the Council: Prevo L. Whitaker, (1943-1947); Roy McKee, (1944-1948); Ruth Wimmer, (1945-1949); Darl F. Wood, (1946-1950); G. Donald Klopp, (1947-1951).

PROGRAM OF THE FIFTEENTH ANNUAL MEETING

October 18, 1947

Auditorium, The Burris Laboratory School
Ball State Teachers College, Muncie

9:00 a.m. Exhibits

10:00 a.m. Morning session, Auditorium, Burris School

General session, Robert Reinhold, presiding.

Greetings, Howard H. Michaud, State Sponsor.

Reading of minutes of the 1946 meeting, Rae Saferight, Secretary.

1. "A Field Trip," Ann Arbogast, Junior Academy of Science Club, Elkhart.

2. "History and Principles of Astronomy," Alan Haber, Central High School Junior Academy, South Bend.

3. "A Trip to the Moon," Harley Sachs, Central High School Junior Academy, South Bend.

4. "The Dunes and William A. Wirt School Grounds," Donald Krebes, Science Club, William A. Wirt High School, Gary.

5. "Coloring and Analysis of Turquoise," Chemistry Club, Shortridge High School, Indianapolis.

1:00 p.m. Afternoon session, Auditorium, Burris School

1. "Tissue Culture of Chick Embryos," James B. Thomas, Science Club, Howe High School, Indianapolis.

2. "Introducing Natural Science to Others," Robert Craig, Biology Club, Lew Wallace High School, Gary.

3. "Marine Invertebrates," Dale Mitch, Biology Club, Lew Wallace High School, Gary.

4. "A Bird Survey of Technical High School Campus," David Schultz, Nature Study Club, Technical High School, Indianapolis.

5. "Stimuli," Phyllis Gouker, 1945 Academy Award Winner, Ball State Teachers College, Muncie.

Business session.

MINUTES

The fifteenth annual meeting of the Indiana Junior Academy of Science was held Saturday, October 18, 1947, in the auditorium of the Burris Laboratory School, Ball State Teachers College, Muncie, Indiana.

The meeting was called to order at 10:00 a.m. by the president, Robert Reinhold, Central High School, South Bend. He next introduced the other officers as follows: Vice President, Marilyn Leech, Science Club, William A. Wirt High School, Gary, and Secretary, Rae Saferight, Science Club, George Washington High School, Indianapolis. Miss Saferight served as secretary for the meeting.

The president introduced the State Sponsor of the Indiana Junior Academy of Science, Professor Howard H. Michaud of the Department of Forestry of Purdue University. Professor Michaud extended greetings to the Junior Academy clubs and spoke briefly of the progress of the Junior Academy of Science during the past year.

As a special surprise, Professor Michaud introduced and called upon Dean Howard E. Enders of Purdue University to speak. Dean Enders who served as the first sponsor of the Junior Academy from 1931 to 1945, urged the clubs to keep a record of the achievements of members after they had graduated. He also related a few of his most interesting experiences of travel during the past year, while on leave from the University.

The first speaker on the program, Ann Arbogast, Junior Academy of Science, Elkhart, presented a talk on "A Field Trip." She outlined the essentials of a field trip, then told of a trip which the Elkhart club had taken to Detroit. She mentioned especially the cooperation of the bus driver, ways to break the monotony while traveling, notification of guides, and planning of extensive tours. She closed with the motto, "Plan your work, then work your plan."

The next speaker, Alan Haber, Central High School Junior Academy South Bend, presented an interesting discussion of the "History and Principles of Astronomy." He explained the term astronomy and spoke of planets, stars, size, orbits about the sun, and of the earlier belief that the earth was flat. He described in detail the "Helio-centric" and "Geo-centric" theories and various other ideas of the early Greeks. Galileo's first discovery of the telescope, his belief in the Copernican theory, and a summation of his contribution to astronomy proved very interesting, as well as, his explanation of gravity. Diagrams were used to illustrate various points of the highly educational talk.

The president next called on Harley Sachs, another member of the Central High School Junior Academy, South Bend, who talked on "A Trip to the Moon". First, he explained the drawings which were on display in the exhibit room. In order to reach the moon, Mr. Sachs said, the rocket would have to leave the equator at midnight and travel at varying, increasing velocities as it progressed toward its destination. He gave definite figures on velocity readings and mentioned the kind of supplies and fuel that would be needed. While the ideas presented seemed somewhat fantastic it is not entirely beyond the realm of possibility.

Donald Krebes, Science Club, William A. Wirt High School, Gary, spoke on "The Dunes and William A. Wirt School Grounds." He explained the formation of dunes, the glaciers involved, the abundance of sand found in the glaciers, and the names of the forms of plant life around the dunes. He concluded by showing kodachrome slides which showed the beauty of the Wirt High School grounds.

The next speaker was Francis Huber, Chemistry Club, Shortridge High School, Indianapolis. He discussed the "Coloring and Analysis of Turquoise," as to discovery of a new method of preparation, the preparation itself, coloring, cleaning, mixing of cleaning solution, polishing, and setting. Two stones were passed around which illustrated a poor and a fine grade of turquoise.

The morning session was adjourned until 1:00 p.m.

The afternoon session was resumed at 1:00 p.m. The first speaker called upon was James B. Thomas, Science Club, Howe High School, Indianapolis, who talked on "Tissue Culture of Chick Embryos." He told about the cultures he had prepared on chick embryos in the laboratory, and the kind of preparations required for study.

"Introducing Natural Science to Others," by Robert Craig, Biology Club, Lew Wallace High School, Gary, was the next presentation. It related the experience of the speaker as a nature counsellor in a summer camp. The kind of teacher and the method of teaching was explained as important in teaching nature to others.

Dale Mitch, Biology Club, Lew Wallace High School, Gary, talked about "Marine Invertebrates." With examples of each, he described sponges, starfish, sea fans, sea urchins, sand dollars, and oysters as to description, enemies, culture, food, habitat classification, damage, reproduction, and structure.

The president then called upon David Schultz, Nature Study Club, Technical High School, Indianapolis, who discussed the topic, "A Bird Survey of Technical High School Campus." He told about robins, woodthrushes, brown thrashers, cardinals, white throated sparrows, woodpeckers, killdeers, yellow warblers, wood pewees, and scarlet tanagers. He mentioned the different kinds of habitat, food, size, and characteristics of each bird. The talk was illustrated with kodachrome slides which were greatly appreciated by the club members.

The final speaker on the program was Phyllis Gouker, 1945 Academy Award Winner, Ball State Teachers College, Muncie, who spoke on "Stimuli." She related what influences had been responsible to cause her to continue in science. She encouraged all of the club members to go on in science and her enthusiasm should prove very stimulating to all of us to work harder in our scientific efforts.

Business session.

Following the last speaker of the afternoon session, the president called upon the State Sponsor to read the list of nominees selected by the council, and the club members balloted for and elected the following officers for 1948: *President*, DONALD KREBES, Science Club, William A. Wirt High School, Gary; *Vice President*, ROBERT CRAIG, Biology Club, Lew Wallace High School, Gary; *Secretary*, JANE NILES, Junior Academy of Science, Elkhart High School, Elkhart.

It was also announced that the council had selected Miss Evelyn Wagoner, biology teacher and sponsor of the Junior Academy of Science at Elkhart to succeed Mr. Prevo L. Whitaker on the council from 1948 to 1952.

The council read its nominations of the "Best Boy" and "Best Girl" of the state for the award of honorary membership in the American Association for the Advancement of Science for the ensuing year. Alan Haber, Junior Academy of Science, Central High School, South Bend, and Ann Arbogast, Junior Academy of Science, Elkhart High School, Elkhart, were chosen by the council and nominated for these honorary memberships. Their selection also entitles them to represent the Indiana Junior Academy at the meeting of the Junior Scientists Assembly in Chicago, December 27.

Approximately one hundred Junior Academy members, sponsors, and friends attended the meeting. Fifteen high school science clubs were represented.

The meeting was adjourned at 3.00 p.m.

EXHIBITS

The exhibits were installed Saturday morning. While the exhibits were rather limited there was a keen interest manifested by members of the visiting clubs as well as those who showed their own club projects. The following clubs prepared exhibits:

Science Club, University High School, Bloomington, Prevo L. Whitaker, Sponsor.

Science Club, Burris Laboratory School, Muncie, Dr. Robert Cooper and Ruth Dutro, Sponsors.

Nature Club, Central High School, Fort Wayne, Iva Spangler, Sponsor.

Nature Club, North Side High School, Fort Wayne, Vesta Thompson, Sponsor.

Science Club, Mishawaka High School, Mishawaka, Darl F. Wood, Sponsor.

Central Junior Academy of Science, Central High School, South Bend, A. L. Smith, Sponsor.

INDIANA JUNIOR ACADEMY OF SCIENCE CLUBS

Name and School	Date Organized	Sponsor
Anderson		
Science	1936	B. B. Harris
Bloomington		
General Science, Jr. H.S.	1931	Harold Stewart
University School-Science	1938	Prevo L. Whitaker
Elkhart		
Junior Academy	1940	N. E. Adams Evelyn Wagoner
Fort Wayne		
Nature Club, North Side H.S.	1936	Vesta Thompson
Phy Chem Club, Elmhurst H.S.	1935	Ruth Wimmer M. Miller
Nature Club, Central H.S.	1939	Iva Spangler
Gary		
Biology Club, Lew Wallace H.S.	1935	Lola Lemon
Klub Kem Club, Lew Wallace H.S.		Mrs. Helen MacKenzie
Beaker Breakers, Edison H.S.	1947	Mrs. Martha B. Conner
Biology Club, Wm. A. Wirt H. S.	1945	Mrs. Frances Huddleston
Indianapolis		
Science Club, Washington H.S.	1937	J. H. Otto
Nature Study Club, Technical H.S.	1932	Howard L. Cook
Chem Club, Shortridge H.S.	1931	William Johnson
Nature Club, Shortridge H.S.	1946	G. Donald Klopp
Marion		
Science Club	1936	Keith Stroup
New Castle		
Biology Club	1947	Edna Banta Max Forsyth
Mishawaka		
Science Club	1936	Darl F. Wood
South Bend		
Central Junior Academy, Central H.S.	1939	
A. Junior Izaak Walton Club		A. L. Smith
B. Junior Audubon Club		A. L. Smith
C. Chemistry Club		
Sullivan		
Camera Club	1940	Ruth Hinkle
Terre Haute		
State Discovery Club		
Laboratory School, Senior H.S.	1939	Russell McDougal

NEW MEMBERS, 1947

Ahrendt, Mr. M. H., Anderson College, Anderson — M
Alexander, Prof. Gerald L., 409 Tillotson Ave., Muncie — C
Allen, Dr. Martin, Dept. of Chemistry, Butler University, Indianapolis 7 — C
Asher, Prof. E. J., Purdue University, West Lafayette — Ps

Babcock, Mr. W. Clay, 508½ W. Charles Street, Muncie — M
Baker, Dr. Lawrence M., Biology Annex, Purdue University, West Lafayette — Ps
Baker, Mr. Linville A., Research Department, Eli Lilly & Co., Indianapolis — Ba
Barton, Prof. Thomas F., 1800 Maxwell Lane, Bloomington — G
Bieber, Dr. Charles L., Geology Dept., DePauw University, Greencastle — G
Bijou, Dr. Sidney W., 400 E. Side Drive, Bloomington — Ps
Boisen, Harold L., 570 E. Fall Creek Drive, Indianapolis 5
Boone, Miss Betty Jane, 2425 Fletcher Street, Anderson — Bo
Bruce, Dr. Robert W., 612 W. Pike Street, Crawfordsville — Ps
Brumfiel, Prof. Charles, 306 N. Talley Street, Muncie — M
Burr, Proof. Irving W., 265 Littleton St., West Lafayette — M
Byrne, Mr. Edward, Jr., 660 Park Avenue, Franklin — G

Caldwell, Mr. A. Lee, 949 E. 86th., R.R. 14 Box 271, Indianapolis 44 — C
Callender, Mr. Maurice E., 1506 Dawson, Indianapolis — Ba, Z
Campbell, Mr. Guy, R.R. 4 Box 1, Corydon — G
Campbell, Mr. M.S.A., Indiana State Board of Health, 1098 W. Michigan Street, Indianapolis 7 — Ba
Campbell, Mr. S. L., Psychology Dept., Indiana University, Bloomington — Ps
Caroline, Mr. Milton, Purdue Housing Court F No. 99, State Street, West Lafayette — Z
Chanin, Dr. Martin, Evansville College, Evansville — C
Clauser, Mr. Charles E., No. 1 Briar Road, Muncie — A
Cohen, Miss Millicent, Biology Dept., Purdue University, West Lafayette — Ba
Cole, Dr. LaMont C., 744 E. 3rd Street, Bloomington — Z
Connor, Mrs. Martha B., 4418 Washington Street, Gary — Bo, Z
Coppock, Mr. Harold, Psychology Dept., Indiana University, Bloomington — Ps
Coverstone, Mr. Harry V., 1207 North 9th Street, Terre Haute — C
Craig, Mr. David R., Psychology Dept., Indiana University, Bloomington — Ps
Crull, Dr. Harry E., 2461 Park Avenue, Indianapolis 5 — M

Davis, Dr. Wm. W., Beech Park, Greenwood — Ph, C
Dearborn, Dr. Robert J., Wabash College, Crawfordsville — C

Dragoo, Mr. Donal W., R.R. 4, Bloomington A
Dreiling, Rev. B. R., St. Joseph's College, Collegeville Ph

Ellson, Dr. Douglas G., Psychology Dept., Indiana University Bloomington Ps
Esten, Mrs. Sidney R., Botany Dept., Butler University, Indianapolis Bo

Fields, Dr. Paul E., Psychology Dept., Wabash College, Crawfordsville Ps
Finn, Miss Theresa, 537 Connecticut Street, Gary C, Ph
Forsyth, Mr. Max Allyn, 714 South 8th Street, Terre Haute Bo, Z
Franklin, Mr. Joseph Charles, P.O. Box 501, West Lafayette Ps
Fritsche, Miss Mary, 2852 Brill Road, Indianapolis 3 Bo
Furgason, Dr. Waldo H., Zoology Dept., Wabash College, Crawfordsville Z

Gage, Miss Margaret E., Mason Hall, Greencastle Ba, Z
Gage, Dr. N. L., Psychology Dept., Purdue University, West Lafayette Ps
Godfrey, Mr. Robert R., 2300 Lafayette Avenue, Terre Haute Bo, Z
Golomb, Prof. Michael, Mathematics Dept., Purdue University, West Lafayette M
Graves, Dr. Gordon Harwood, 227 South Grant Street, West Lafayette M
Graybrook, Miss Irene, 520 State Street, New Albany Ba, Bo, M
Gross, Mr. E. Wayne, 303 East 6th Street, Bloomington Ph
Gunsalus, Dr. Irwin C., Bacteriology Dept., Indiana University, Bloomington Ba

Hanna, Mr. Ray, 321 South Meridian, Jasonville Bo, C, Ph, Z
Harker, Mr. David H., Centerton G
Hazard, Prof. Clifton T., 344 Northwestern Avenue, West Lafayette M
Heiser, Jr., Dr. Charles B., Botany Dept., Indiana University Bloomington Bo
Heller, Mr. Noah C., Science Dept., Indiana State Teachers' College, Terre Haute C
Helmen, Mr. Vernon R., 208 Murray Street, South Bend A
Hiatt, Mr. George A., 5545 Rockville Road, Indianapolis M, Ph
Hill, Mr. Charles F., 1132 Blaine Avenue., Indianapolis Bo
Hoagland, Mr. John Edward, 4527 Young Ave., Indianapolis 1 Ph
Holmes, Dr. Arthur, College of Religion, Butler University, Indianapolis Ps
Hoshaw, Mr. R. W., 703 Evergreen Street, West Lafayette Bo
Hughes, Mr. Norwood R., Jamestown M
Hummel, Dr. A. D., Physics Dept., Ball State Teachers' College, Muncie Ph

Johnson, Mr. L. W., 44 North Salisbury Street, Lafayette M
Johnson, Mr. Paul E., 324 Sheetz Street, West Lafayette Ph
Jonah, Prof. H.F.S., Mathematics Dept., Purdue University, West Lafayette M

Karst, Charles E., Mishawaka High School, Mishawaka C
Kent, Mr. George N., 431 Lowell Street, Manchester, N. H. Bo
Keyler, Mr. Robert Dean, 3122 North Keystone, Indianapolis Bo, G

Kleiderer, Dr. Ervin C., 5105 N. Illinois Street, Indianapolis 8 C
W. Lafayette Ba
Koffler, Dr. Heinrich, No. 75, Purdue Housing, West State Street,
Koenker, Prof Robert H., 3000 Riverside, Muncie Ps
Konopinski, Prof. Emil J., Physics Dept., Indiana University,
Bloomington Ph
Kossack, Prof. Carl F., Mathematics Dept., Purdue University,
West Lafayette M
Krekeler, Mr. Carl H., 360 McIntyre Court, Valparaiso Z

Lauterbach, W. Walter, Central High School, South Bend Bo, Z
Lawrence, Mr. John O., 3212 East Hulman Street, Terre Haute C, Z
Ledgerwood, Dr. Richard Carnes, Education Building, Purdue Uni-
versity, West Lafayette Ps
Lemler, Mr. Everett H., Bourbon, Indiana Ph
Lindsey, Dr. Alton A., 57-D West State Street, Lafayette Bo
Loring, Mr. Robert D., 2361 Valentine Ave., Bronx, New York 57,
New York G
Luria, Mrs. Zella H., Psychology Dept., Indiana University, Bloom-
ington Ps

Machata, Miss Helen, Biology Dept., Purdue University, West
Lafayette Ba
Marks, Mr. Robert L., 306 South Main Street, Jersey Shore, Pa. G
Marling, Bro. John A., St. Joseph's College, Collegeville Ph
Miller, Mr. Chester Wayne, 4110 E. 10th Street, Indianapolis Bo
Miller, Mr. Garrett Hobert, R.R. 1, Paxton G
Mitchell, Mr. Howard W., 1508 North Seventh Street, Terre Haute C, Z
Myer, Mr. William H., 3955 College Avenue, Indianapolis 5 Bo
Myers, Mr. William Andrew, 3955 College Avenue, Indianapolis 5 Bo

Niles, Mrs. Louise A., Eli Lilly & Co., Research Building Room 165,
Indianapolis Ba

Ofiesh, Mr. Gabriel D., Psychology Dept., Butler University, Indi-
anapolis Ps
Osterhoust, Miss Josephine, Lilly Research Laboratories, Eli Lilly
& Co., Indianapolis Ba

Patton, Mr. John B., Geology Dept., Indiana University, Bloomington G
Poe, Miss Elisabeth, Marion College, Marion Bo, Z

Rath, Miss Lila Jean, Dept. of Botany & Plant Pathology, Purdue
University, West Lafayette Bo
Reimer, Mr. Charles W., R.R. 2 Box 563-B, Indianapolis 44 Bo
Reynolds, Dr. Thomas E., R.R. 1 Box 226, Michigan City A, C, G, Z
Rosenthal, Prof. Arthur, Recitation Hall, Purdue University, West
Lafayette M
Rostofer, Dr. Howard H., R.R. 1, Bloomington Z
Rudd, Mr. Robert, Indiana State Teachers' College, Terre Haute C, G
Rushton, Mrs. LaVella, 528 South Street, Noblesville Ba
Ruster, Mr. Marvin H., 325 South Butler Avenue, Indianapolis Ba

Sauer, Miss Pauline L., 226 W. Jackson Blvd., Elkhart Bo
Schultz, Jr., Dr. Fred H., 2266 Deming Street, Terre Haute C, Z
Shaffer, Mr. Robert E., 2013 South Gate Avenue, New Castle Bo, Z
Shepherdson, Prof. Wayne, Huntington College, Huntington Ph
Shuyler, Mr. Harlan R., Cottage Grove, R.R. 1, Lafayette E
Sidebottom, Mr. Kenneth J., 1397 Windermire Street, Indianapolis 3 M
Smith, Prof. Aubrey H., Mathematics Dept., Purdue University, West Lafayette M
Smith, Miss Jean, 725 N. Pennsylvania, Indianapolis Ba, C
Smolar, Rev. Joseph, St. Joseph's College, Collegeville Bo, Z
Smucker, Mr. Silas J., 403 S. Weston Street, Rensselaer Bo
Sparks, Prof. Blair W., 4151 North Graceland, Indianapolis Ps
Stokes, Mr. John J., Jr., 301 McKinley Street, Valparaiso C
Streitelmeier, Mr. John H., 1082 Linnwood Ave., Valparaiso G
Sturm, Miss Tillie, 2030 W. 5th Ave., Gary Bo, Z
Sullivan, Mr. Gerald, 1017 North Harrison Street, Alexandria Bo, Z
Summers, Mr. Robert M., Chemistry Department, Indiana University, Bloomington C

Taylor, Miss Edith S., Anthropology Dept., Indiana University, Bloomington A
Thomas, Mr. Virgil A., 810 North State Street, Greenfield Ba, C
Truman, Dr. Lee C., 2701 Winthrop Avenue, Indianapolis E

Van Dyke, Prof. John H., School of Medicine, Indiana University, Bloomington Z
Van Liere, Mr. Donald W., 1306 North Fess Avenue, Bloomington Ps
Vernberg, Mr. Frank John, Box 239, Greencastle Z
Voigt, Mr. John W., 3013 Harrison Avenue, Terre Haute Ph

Waddell, Mr. Courtney, 2431 E. Riverside Drive, Indianapolis G
Wagner, Dr. William F., Hanover College, Hanover C
Wagoner, Dr. Kenneth S., Psychology Dept., DePauw University, Greencastle Ps
Wallace, Dr. William J., Dept. of Anthropology, Indiana University, Bloomington A
Watanabe, Dr. Kenichi, Wabash College, Crawfordsville Ph
Weaver, Mr. Jack R., 1406 E. 5th Street, Anderson Bo, Z
Webb, Prof. Richard L., 1408 Maxwell Lane, Bloomington Z
Wegrich, Dr. O. G., Commercial Solvents Corp., Terre Haute Bo
Weigand, Dr. Clayton G., 5234 North Capitol Street, Indianapolis Z
Welshimer, Dr. Herbert J., Dept. of Bacteriology, Indiana University, Bloomington Ba
White, Prof. Virginia B., Home Economics, Purdue University, West Lafayette Bo
Wier, Mr. Charles E., R. F. D. 2 Box 118, Jasonville G
Wiggin, Mr. H. Carvel, Dept. Botany & Plant Pathology, Purdue University, West Lafayette Bo
Williamson, Mrs. Marjorie H., Psychology Dept., Purdue University, West Lafayette Ps

Wilson, Mr. Mark Curtis, 503 University Street, West Lafayette **Bo, Z**
Wise, Mr. Morris William, 426 S. Main Street, Hillsboro, Illinois **G**
Wiseman, Dr. P. A., Ball State Teachers' College, Muncie **C**
Wunder, Mr. Charles N., 314 West Lutz, Lafayette **M**

Yarnelle, Mr. John E., Hanover University, Hanover **M**

Zirkle, Dr. George A., Hanover College, Hanover **Ps**

JUNIOR ACADEMIES

Beaker Breaker Science Club, Edison School, 5th Avenue at Burr St., Gary **Bo, Ph, Z**

New Castle Biology Club, New Castle High School, New Castle **Bo, Z**

NECROLOGY

Will E. Edington, DePauw University

Severance Burrage

West Newton, Massachusetts
July 18, 1868

Denver, Colorado
April 11, 1945

Severance Burrage might be considered a pioneer in sanitary science and bacteriology for his life span covered the period during which most of the great developments in those fields have occurred. He was born in 1868, which was just two years before the first filtering plant for water purification in the United states was built at Poughkeepsie, New York. Sanitation was then virtually unknown in the medical profession. Pasteur and Koch were busy with their epoch making experiments that led to the establishment of the germ theory of disease through publications by Koch in 1876. Bacteriology was practically unknown and Lister had not yet made much of an impression on the medical world.

Following the usual public school education Burrage entered the Massachusetts Institute of Technology and received the B.S. degree in 1892. After three years of teaching at the Institute he came to Purdue in 1895 where he devoted the next seventeen years to teaching and organizing and building up a department of Sanitary Science. He joined the Indiana Academy of Science in 1895 and presented his first paper before the Academy that Fall on "Sanitary Science in the Modern College." The following year he gave the results of his studies on the water supplied in Lafayette. At that time purification by filtering was the general method, for studies on chlorination were just beginning in England and it was twelve years later before the first systematic treatment of water supply was made in the United States. Burrage regularly appeared before the Academy with reports on his bacteriological studies, and in 1902 he discussed "Transmissible Diseases in College Towns," and "Sewage Disposal of the Indiana State Reformatory at Plainfield."

In 1912 Dr. Burrage joined Eli Lilly and Company and during the next few years was active in the development of the manufacture of biological products. He returned to the East in 1916 as assistant biologist for the Massachusetts State Board of Health. A year later he served on a Red Cross Medical Commission in Serbia and Greece. On his return he entered the United States Public Health Service and did work at Waco, Texas, and Denver, Colorado. In 1920 he was appointed Assistant Professor of Bacteriology in the School of Medicine of the University of Colorado, then located at Boulder, and when the Medical School was moved to Denver in 1924, Dr. Burrage took up his residence in that city.

He retired in 1936 as Associate Professor of Bacteriology and Public Health, Emeritus, but still kept his office at the Medical School, teaching whenever needed, doing bacteriological work at the Hospital, and lecturing in the School of Nursing. He also taught in several summer sessions of the University of Denver and was teaching in Loretto Heights College at the time of his death.

While in Indiana Dr. Burrage was active in health work and served as president of the Indiana Tuberculosis Society. He was also active in the Indiana Conservation Association. He was vice-president of the Indiana Academy of Science in 1913 and president in 1914. In 1917 he was elected a Non-Resident Fellow of the Academy, having been made a Fellow in 1898. He became a member of the Rotary Club in Indianapolis, continued his membership in Boulder, and was an active member of the Denver Club at the time of his death. He was a Fellow of the American Public Health Association, and of the American Association for the Advancement of Science. He wrote a number of scientific papers and was the author of a book "School Sanitation and Decoration."

A genial and kindly man, he had many friends and was never known to have an enemy. He was popular with his students and was affectionately known to them as "Bugs." He had a high minded sense of duty to his profession and to the people whom he served, both in his teaching and in his public health work. His hobbies were golf, music and dramatics, and he took part in many plays at the Denver Civic Theater. He was also active in the Ben Franklin Club, a discussion group, composed of prominent Denver men.

Dr. Burrage had not been active in the Academy for a number of years. He had planned to attend the Fiftieth Anniversary Meeting in 1934, but the death of a daughter at that time prevented it. He will be remembered in Indiana as one of that group of health scientists which included such members of the Academy as Harvey W. Wiley, John N. Hurty and Robert Hessler.

JEDIAH H. CLARK

Carthage, Indiana — Macon, Georgia
July 30, 1868 — September 22, 1946

Dr. Jediah H. Clark was born near Carthage, Indiana, of Quaker parents. Completing his public school education he entered Earlham College, and later graduated from Indiana Medical College at Indianapolis. Following his graduation he joined the staff of the Insane Hospital at Evansville, and later transferred to East Haven Hospital at Richmond, and became recognized as an insanity expert. In 1901 he took up the general practice of medicine in Connersville, where he remained until his retirement in 1937. He and Mrs. Clark then made their home in Winter Park, Florida, but they returned frequently to Indiana, and it was on one of these returning trips that he was fatally injured in an automobile accident near Macon, Georgia.

Dr. Clark was much interested in plants and trees and spent much of his spare time in their study. After his retirement he devoted most of his energy to the culture of subtropical plants, shrubs and trees, and his garden became a show place. His interest in science, particularly bacteriology and botany, led him to join the Academy in 1909, and despite his general medical practice he was occasionally able to attend a spring meeting.

He was one of the leading physicians in his part of the State, and served at one time as president of the Fayette-Franklin Medical Society. He was also secretary of the Connersville Board of Health for a number of years. He had membership in several medical societies and also in the American Association for the Advancement of Science. Active in civic affairs he had been a member of the Rotary Club in Connersville, and he was prominent in Masonry, being a member of the Murat Shrine and Scottish Rite at Indianapolis.

Dr. Clark possessed a charming personality. He loved poetry and could recite long passages from his favorite authors. He enjoyed expressing his own thoughts in poetic form and frequently on programs of the local medical society he gave his part in rhyme. Genteel and soft spoken, Dr. Clark was a man of deep religious convictions whose life was devoted to serving and beautifying, in his quiet way, the world about him.

CORA B. HENNEL

Evansville, Indiana — Bloomington, Indiana
January 21, 1886 — June 26, 1947

With the death of Cora B. Hennel Indiana lost one of its finest teachers of college mathematics and one of its most influential college women. For over forty years she was associated with Indiana University. After graduating from Evansville Central High School she entered the University in 1903 and received her A.B. degree in 1907. She held a teaching fellowship the next two years, but completed her work for the Master's degree in 1908. Appointed to an instructorship in the Department of Mathematics, she continued her graduate study and became the first student in Indiana University to receive the Ph.D degree in mathematics, which was conferred on her in 1912. She was promoted to Assistant Professor of Mathematics in 1916, and then to Associate Professor seven years later, and she received the full professorial rank in 1936.

Dr. Hennel had through the years been very active in campus affairs. She had served as the president of the Indiana University chapters of the American Association of University Professors, the American Association of University Women, Women's Faculty Club, Y.W.C.A. Board, and the Cosmopolitan Club. For a number of years she was advisor to foreign students. She had also served on various university faculty committees. She was a member of Phi Beta Kappa, Sigma Xi, Pi Lambda Theta, and Mortar Board.

When the Indiana Section of the Mathematical Association of America was established in 1924, Miss Hennel was one of the charter members and she served as its chairman in 1941. She regularly attended the meetings of the national organization. She was also a member of the American Mathematical Society. Dr. Hennel first joined the Academy of Science in 1913 and, except for a few years, she had been active in the mathematical section of the Academy since that time. She had published a few papers and was co-author with Dr. Harold T. Davis, now at Northwestern University, of a book on "General Mathematics."

Dr. Hennel was well known throughout the State, having addressed numerous Indiana University alumni groups, and various educational, professional and civic organizations.

However, Dr. Hennel's chief contributions were in her excellent teaching and her influence on many students, both native and foreign, who relied on her for friendly advice and wise counseling and guidance. She maintained a sincere and devoted interest in her students and in her quiet and unobtrusive way she encouraged and helped many of them not only through counseling but financially as well. In the words of President H. B Wells, of Indiana University, "she was one of the persons who made our Alma Mater unique. Her devotion, loyalty, interest in students, and teaching skill made her service a true expression of the Spirit of Indiana."

HUGH MCKENNAN LANDON

Muscatine, Iowa — Indianapolis, Indiana
June 22, 1867 — April 2, 1947

Hugh McK. Landon, a member of this Academy and one of the most useful of the citizens of Indiana, passed away in April, 1947. Mr. Landon was born in Muscatine, Iowa, June 22, 1867, and at the time of his death was nearing his eightieth birthday. While young he came to Indiana with his family where he spent most of his life.

He was prepared for college at Phillips Exeter Academy and entered Harvard in the fall of 1888, graduating magna cum laude in 1892. He was chosen class orator, elected to Phi Beta Kappa and received several other scholastic honors.

In the fall of 1892 he came to Indianapolis and became connected with the Manufacturers Natural Gas Company, later with the Indianapolis Water Company where he remained as an official until its sale in 1912. In 1920 he was elected executive vice-president and chairman of the executive committee of the Fletcher Trust Company in which connection he continued until his death.

Mr. Landon was a man of commanding presence and great dignity though modest, sympathetic and gracious in all his relations. Men naturally looked to him for guidance because they could trust his integrity and his judgment.

He was a tower of strength to any institution or cause which enlisted his support. He gave generously of his purse and time to movements for civic betterment. Organizations for the children and young people made a special appeal to him. Boy's clubs, wholesome recreational projects, the Riley Hospital for Crippled Children, Goodwill Industries, and the like owe much to him.

His public service was unselfish, wholehearted and inspiring to others. His interest in educational and cultural institutions was unfailing and he was the recipient of honorary doctorate degrees from both Wabash College and Indiana University.

During foreign wars he served his country on important civic assignments.

In his long business career he acquired an ample fortune, was almost continuously associated with public utilities and large financial institutions, but demonstrated by his life that such relations need not corrode character, nor are they incompatible with unselfish public service.

In Mr. Landon we saw an example of the purpose which John Milton in the 17th century declared a humane education should accomplish, namely, to fit a man "to perform justly, skillfully and magnanimously all the offices, both private and public, of peace and war."

Mr. Landon's passing leaves a void in the ranks of those who labor for the good of the city and the state.

John S. Wright.

ROBERT EDWARD LYONS

Bloomfield, Indiana — Bloomington, Indiana
October 24, 1869 — November 25, 1946

The history of science in Indiana is the history of the lives of a few great men. The history of chemistry in Indiana will ever be associated with the names of Harvey W. Wiley, John Ulric Nef, Thomas C. Van Nuys, William A. Noyes, Robert Warder, Alexander Smith, Winthrop E. Stone, Richard B. Moore, Father Julius A. Nieuwland and Robert Edward Lyons. All these men were either pioneers in the development of modern chemistry departments in our colleges and universities or their achievements have brought scientific distinction to the State.

The history of the chemistry department at Indiana University, as we know it, dates back to David Starr Jordan as president and the coming of T. C. Van Nuys to Indiana, but the development of the department to the eminence it now enjoys is due to Robert Edward Lyons.

Robert Edward Lyons was born in Bloomfield, Indiana, October 24, 1869. He entered Indiana University at the age of sixteen, and in 1888, at the age of nineteen, gave evidence of his unusual ability by presenting a joint paper with T. C. Van Nuys before the Indiana Academy of Science. Following his graduation in 1889 he was appointed instructor in chem-

istry, but he continued his graduate study and was awarded the M.A. degree in 1890. He gave further joint papers with Van Nuys in 1890 and 1891 and two papers of his own in 1890. His ability and research promise led to his promotion to an assistant professorship in 1890 and to an associate professorship the following year. He left for Europe in 1892 to spend the next three years in Germany and Denmark as a student in Fresenius' Laboratory in Weisbaden, and in the Universities of Heidelberg, Munich and Berlin, and in Joergensen's Institute for Physiology of Fermentation in Copenhagen. The University of Heidelberg conferred the Ph.D. degree on him in 1894 and he spent a part of the next year at that university as private assistant to Professor Krafft. Upon his return to America in 1895, at the age of twenty-five, he was made Head of the Department of Chemistry at Indiana University and he continued in that capacity until his retirement as Professor, Emeritus, in 1938.

Dr. Lyons not only served Indiana University as head of the Department of Chemistry for forty-three years but he also served the State as Chief Chemist for State Department of Geology and Natural Resources from 1900 to 1915, and as chairman of the Department of Chemistry of the Indiana University School of Medicine at Indianapolis from 1907 until retired. He also conducted research for a number of industrial concerns including the Guggenheim Foundation, and he was the inventor of a number of chemical processes among which are the "Lyons Method" for the amalgamation of platinum and of refractory gold, the recovery of soap from laundry suds, the rapid polymerization and oxidation of drying oils, the recovery of pectin from certain fruit and vegetable wastes, a process for silver and gold mirror decoration, the reduction of nitro compounds, and a process for light and weatherproof coloring of oolitic limestone.

He was the author of numerous research papers on physiological, synthetic, organic and analytical chemistry, published in American and German scientific magazines. He directed the research of numerous candidates for master's and doctor's degrees and encouraged these beginners in science by jointly appearing with them, as he had done with Van Nuys, on programs of scientific societies and in the publication of the results of their joint research. He frequently made use of the Academy of Science in this way as a training ground for these beginners in having them appear before the less critical audiences to be found in the Academy. He was the author of a textbook on "Qualitative Analysis of Inorganic Substances," in 1897, of which a second edition appeared in 1900, and of a "Manual of Toxicological Analysis" which was published in 1899.

Dr. Lyons was a Fellow of the American Association for the Advancement of Science, the American Institute of Chemists, the American Chemical Society, and the Indiana Academy of Science, and a member of the Deutsche Chemische Gesellschaft. He served on the Council of the American Chemical Society in 1909 and was president of its Indiana Section in 1908. He was also a member of Sigma Xi, Alpha Chi Sigma and Nu Sigma Nu. During the war period he served on the State Council of Defense.

The passing of Dr. Lyons removes another one of the very few remaining ties to the glorious scientific past of Indiana University and the Indiana Academy of Science. Dr. Lyons drew his inspiration from David Starr Jordan, Thomas C. Van Nuys and Joseph Swain, and he was able, through the years, to pass on the scientific torch to his many students who are now scientific leaders in this and other lands. Retiring and unostentatious as he was, he nevertheless was kindly and sympathetic in his dealings with others, and he left his scholarly impress in all his work. He has gone to join the "Giants of Other Days."

WILLIAM J. MOENKHAUS

Huntingburg, Indiana — Bloomington, Indiana
January 6, 1871 — June 7, 1947

William J. Moenkhaus was one of a distinguished group of Indiana born scientists who graduated from their State University and remained there most of the remaining years of their lives. He was born in Huntingburg, the little community in southern Indiana that also produced the three distinguished Rettger brothers whose sister Dr. Moenkhaus later married. After completing the work offered in the public schools of Huntingburg he entered Indiana University, graduating in 1894 and receiving the Master's degree the year following. He spent the next year at Indiana University as an instructor in zoology and then entered Harvard University for two years of further study. In 1898 he accepted the opportunity to spend a year in Sao Paulo, Brazil, as an assistant director of the State Museum. Upon his return to the United States he taught one year in Williams College and the year following in Rush Medical College. During this latter year he also began graduate study in the University of Chicago from which he received the Ph.D. degree in 1903. In 1901 he was appointed Assistant Professor of Zoology in the School of Medicine at Indiana University. Three years later he was promoted to Associate Professor of Physiology, a year later Junior Professor, and in 1908 he was made Professor and Head of the Department of Physiology which position he held until his retirement as Professor Emeritus in 1941.

Dr. Moenkhaus did a great deal of research and was the author of numerous papers. He was considered sufficiently outstanding by his fellow scientists to receive admission to the group known as the "Starred Men of Science." In his younger days he frequently presented one or more papers before the Indiana Academy of Science. He was a member of the Society of Naturalists and was its secretary for five years. He was also a member of the American Zoological Society. He became a member of the Indiana Academy of Science in 1893, was made a Fellow in 1901, and became its president in 1917. He also served as its treasurer from 1909 to 1913.

For many years Dr. Moenkhaus was the Indiana University faculty representative in the Western Conference, better known then as the "Big Ten Conference." He was deeply interested in athletics and both

at Indiana University and in the Conference he used his influence to maintain standards in amateur athletics. For a number of years he was chairman of the Conference faculty committee.

Dr. Moenkhaus was a sympathetic, inspiring and effective teacher. His lectures were very carefully prepared and his presentations and explanations were clear and convincing, impressing his students with his wisdom and sincerity. He was another one of Indiana's great teachers of science who will be long remembered and revered by the hosts of medical students who sat at his feet through the forty years during which he served his University and his State so faithfully and so well.

HORACE ABBOTT SHONLE

Tuscola, Illinois — Indianapolis, Indiana
May 14, 1892 — February 24, 1947

Horace Abbott Shonle, director of the Organic Chemistry Division of the Lilly Research Laboratories, died of pneumonia February 24, 1947 after a brief illness.

Mr. Shonle was born in Tuscola, Illinois, May 14, 1892. He graduated from the Tuscola High School in 1910. The University of Illinois conferred the degree of Bachelor of Science in chemistry on him in 1916 and the Master of Science in chemistry one year later. During 1918 and 1919 he was a research chemist with the Chemical Warfare Service and has seen service with the United States Department of Agriculture and with the Agricultural Experiment Station, Urbana, Illinois. He was employed by Eli Lilly and Company in chemical research in 1919.

Mr. Shonle was responsible for the development of important barbiturates and was an outstanding national authority on the chemistry of the barbiturates. He was joint author of a paper published in 1916, "The Origin of the Nitrates in the Urine," H. H. Mitchell, H. A. Shonle, H. S. Grindley (Univ. Ills.), J.Biol.Chem., *24*, 461-90 (1916), covering work carried out during his junior year at the University of Illinois. He was the author of "The Organic Chemist" and was author and joint author of many papers and patents; author of chapter "Manufacture of Pharmaceuticals," 6th Ed., Rogers' Industrial Chemistry. Member of Board of Editors of the Journal of Organic Chemistry; past secretary and chairman of Indiana Section of American Chemical Society and Division of Medicinal Chemistry of the American Chemical Society; past chairman of Division of Biological Chemistry, American Chemical Society. Member of Phi Lambda Upsilon, Sigma Xi, Alpha Chi Sigma, Cosmopolitan Club, American Association for Advancement of Science, American Pharmaceutical Association, Indiana Academy of Science, Scientech Club of Indianapolis, Meridian Hills Country Club, Second Presbyterian Church, Indianapolis Literary Club, Century Club. Member of the Board of Mayer Neighborhood House, active in Boy Scout work and taught Sunday School class.

John S. Wright

PRESIDENTIAL ADDRESS

Graduate Degrees for College Science Teachers

J. F. MACKELL, Indiana State Teachers College

Some years ago the late Will Rogers was being escorted through Davis Gardens at Terre Haute. What met his eye was a vast acreage under glass devoted to the culture of "bigger and better" cucumbers. Will rubbed his chin in the characteristic manner and said, "Gosh! I never knew anyone ever tried to grow those things on purpose". If we are to put any credence upon the opinion of educators in general and upon the comments of college students by and large we might be forced to the conclusion that college instructors "just happen", and that too many of them make little pretence of being good teachers. As a matter of fact, the able scientist might feel that if he were known as a good science teacher, some doubt might be cast upon his ability as a researcher.

During the past year an interesting sidelight bearing on this situation was brought to my attention. A young man graduate from one of our smaller colleges was being interviewed by the head of a Science Department in one of our leading state universities. This young man had been recommended for a graduate assistantship in the department. After looking over the young man's credentials and asking him a few questions, the department head said, "Well, I don't think you have the ability nor the background which would make it possible for you to pursue graduate work successfully in the department, but we do need some extra instructors for our Freshman Classes. I'll recommend your appointment, but go easy on the graduate work". If this is a sample of the type of instruction being handed out to our science freshmen in the universities, maybe it is time for scientists to do something about it.

It might be worthwhile at this time to attempt to find out what the future needs will be for well-trained science teachers on the college level. We all know of course that our colleges and universities are overflowing with students, with thousands turned away for lack of facilities. Many of us last year thought this was a mere temporary affair which would vanish as soon as the G.I.'s had a sample of the rigors of higher education, but of course we all know now that such was not the case. The ex-service men liked the sample and cried for more. This fall, enrollments are higher than ever and the ex-service men who couldn't get in last year are taking over the places vacated by the few who had enough last year. Yes, more people are going to college than ever before and the trend is still upward. In 1940 there were approximately one million five hundred thousand students enrolled in colleges and universities in the United States. In 1930 there were approximately one million, while in 1920 there were about six hundred thousand. In 1946, there were well over two million and by 1950 most conservative estimates put the figure at nearly three million.

Another factor which will tend to increase future college enrollment is the increasing number of high school graduates. Just before we entered the war in 1941, seventy three per cent of the young people of high school age were actually enrolled in high school classes. The number fell off in the upper two years of high school during the war period, but now that the war is over the upward trend is here again. More and more young people are graduating from high school and conservative estimates set the figure at eighty per cent by 1950. There is no reason to doubt that an increasing number of high school graduates will enter college in the years to come if the colleges and universities can offer attractive opportunities for further study. Parents and young people as well realize that education for a profession offers the best guarantee of future dividends.

Science departments all over the country are feeling the impact of this upsurge in a manner which is not surprising. Most of the phenomenal increase has been in men students; and men students by and large are more likely than women students to elect science courses. In addition to this the war was widely advertized as a scientific war. The public in general realizes that we are living in a scientific age. The radio, the press, and even the pulpit are whooping it up for science until the scientist himself is having a difficult time trying to ward off idolatry. If ever there was a time for intelligent and purposeful instruction in the sciences, now is that time.

That there is a very definite shortage of well-trained and competent teachers in all schools from the kindergarten through the university no one will deny. The shortage in the colleges is especially acute in the sciences and mathematics. Everyone knows that a major part of the instruction given to our university freshmen in the sciences is carried out by young graduate assistants who do this work rather reluctantly as a means of supporting themselves in their principal work, scientific research. About the only acquaintance that a young science student ever has with a real science professor in the University is in the occasional lecture which he attends along with several hundred or perhaps a thousand other freshman. The real instruction comes when he meets with a smaller section under the guidance of a young instructor or graduate assistant. In my opinion, the average lecture attended by several hundred college freshmen falls far short of meeting the requirements for good instruction. It is true of course that the universities are replete with big name scientists, men who know what there is to know about science, but I am afraid the average freshman in physics, chemistry and biology rarely comes in contact with them.

That there is a definite shortage of instructors in the colleges and especially in the sciences one can see in a minute by comparing student-teacher ratios before the war and now. Before the war, the national average for all colleges was ten to one. This figure was accepted for forty years as fair and workable. Now the figure is nearly twenty to one. Added to this we must remember that the quality of instruction has deteriorated due to a shortage of well equipped teachers. If we consider the ten to one ratio desirable for efficient instruction, it is

conservatively estimated that we will need about 90,000 new full time college instructors by 1950. It goes without saying, of course, that the natural sciences will need their full share, probably one-fifth of this number.

Before the war, in the decade 1930-40 approximately 34,000 university doctorates were granted, about 3400 per year. Of these somewhat less than half that number, about forty per cent entered teaching as a profession. We are now some ten thousand staff members short, not to mention the positions occupied by instructors and graduate assistants who are poorly trained and should be replaced. This shortage is certain to grow.

Our experiences in the war have made it clear that we may have to rethink our philosophies of Education. Many college graduates and thousands of high school graduates have secured diplomas and degrees in the past without touching upon some of the vital areas of human knowledge. Thousands of college graduates in the past have never looked through a microscope nor have they had anything but a passing glimpse of scientific method. The Harvard report, the Princeton report, the Yale report and many others all point to the same conclusion. If we expect higher education really to do anything vital for the great masses of young people who are seeking college degrees, we must do something about general education. A vital part of general education must needs be concerned with science education, the scientific method and the contributions of natural science to human well being. We are going to need a competent staff of well trained, versatile science instructors for this task. The physics instructor will need to know something about chemistry, biology, geology, astronomy to say nothing of psychology and sociology. The atom is no longer the sole property of the chemist nor is the X-Ray the sole property of the physicist.

The Scientist, whether he be a teacher or a researcher is being asked by the layman to assume some social responsibility for scientific discoveries and their applications in the engineering, agricultural and medical fields. Diplomats, congressmen and clergymen as well as journalists and commentators are disturbed about where science is leading us. Are all these new scientific discoveries leading us to a realization of the "four freedoms" or are we heading for international suicide? The scientist cannot afford to leave the decision up to chance, nor can he afford to leave it up to the rabid militarist or the rabble rousing politician. There is a race on now among the great powers to assemble the best scientific brains to get there "fustest with the bestest" scientific army. Whether this great army is to be destructive or constructive is to a large part the responsibility of science itself. Science instruction in the future must be more than mere research into the laws of nature. We scientists cannot afford to ignore the social and moral implications.

It cannot be denied that college administrators and department chairmen are aware of the fact that there is a need for more and better trained teachers in all the sciences and we find isolated instances of attempts to improve science instruction. In the July-August 1947 number of the American Journal of Physics a pertinent article by A. G.

Worthing of the University of Pittsburgh Physics Staff deals in some detail with "A Basic Concept Course in Physics". This course had its origin in a desire to insure that teaching assistants in the department understood the basic concepts in the course and that they be capable of presenting these concepts to students under their charge clearly and consistently. In this basic concepts course in the fall of 1946 there were enrolled 56 graduate students mostly majors in physics but some majoring in other closely related fields. The course carries three semester hours of graduate credit for two semesters. The method employed in the course by Dr. Worthing is one of free discussion in which all the students participate openly to their heart's content. Much time is spent on problem solving and on the discussion of erroneous concepts. Clear and consistent definitions of physical terms are emphasized and mathematical short cuts are stressed. The course is popular with the graduate students because they see a direct application to their teaching. I heartily agree with Dr. Worthing in his concluding statement, "A course in the basic concepts of physics at the senior and the first year graduate level is very worth while." Furthermore, I have no doubt that a similar type of graduate course could have a definite place in any of the other natural sciences. This venture at the University of Pittsburgh to professionalize the teaching of physics is a noble gesture in a small though significant way.

Our graduate schools since the war are filling up again with thousands of young men and women looking forward to professional careers. In the sciences we have the professions of engineering, medicine, scientific research and teaching. Probably one half of the young Ph.D.'s in the Sciences during the next decade or two will try to apply their graduate training to the field of college teaching. These young people should be selected early in their graduate training. The graduate schools should devise some sort of aptitude examinations which have been skillfully prepared for the purpose of selecting future college and university instructors. Insofar as this applies to the sciences, I am not in any way attempting to divert anyone from a research career if his aptitudes and desires point in that direction. The Universities and industry as well will need all the research talent available in the forseeable future, but I do not think it is fair to the teaching profession nor to the young people who are to be our future scientists if we do not furnish them with the best scientific instruction possible in the first two years of college. Our graduate science schools should attempt to train specialists in undergraduate and graduate instruction in the sciences just as they now train research specialists in nuclear physics, organic chemistry, bacteriology, parasitology, minerology and vertebrate anatomy.

The teacher of science should by all means first and foremost know his subject matter. In all probability he should be encouraged to have a specialty in which he should be urged to continue research as a part of his teaching load. Too many college instructors today complain that they are so heavily burdened with teaching, grading papers and committee assignments that they have neither time for

research nor for further study leading to professional growth. Department heads and college administrators should see that this be not so. Good teaching, no less than productive research should bring professional rewards in the way of promotion in rank and better salaries.

If graduate schools are to train better science teachers, these teachers must be trained in breadth as well as in depth. Physics, chemistry, and biology are all broad fields. Moreover, they are all overlapping and inter-related. Most of the students that college science instructors are going to meet are not going to be specialists in any of the sciences but they are going to be voters, tax payers and citizens. They should be given such science instruction as will best fit them for their future role in society. Science has a lot to offer and it must not be cheapened by poor and indifferent instruction.

Since it is entirely likely that some fifty per cent of our future recipients of graduate degrees in the sciences will enter the field of college teaching it seems entirely fitting that our science graduate schools should set up appropriate curricula for best meeting the needs of this group. This could be done without in any way cheapening the degrees nor lowering standards. Perhaps narrow departmental barriers will have to be crossed in order that our future college science instructors may have a broad cultural background. Perhaps basic concepts courses on a graduate level in biology, chemistry and even sociology and psychology might be extremely profitable for the physics graduate student who intends to enter the profession of college teaching. Similar reasoning might well be applied to graduate students in the other natural sciences including mathematics. Nature after all is not departmentalized; an oak tree is more than a botanical specimen, and stars, planets and nebulae are not the sole property of astronomers.

During the war our government together with others engaged in the war on both sides enlisted the services of the best scientific brains in the world for the purpose of winning the war. Since the ending of hostilities the federal government and industry as well are making every effort to encourage scientific research. Even on the secondary school level we see such enterprises as the "Westinghouse Search for Science Talent". All these gestures of recognition are extremely gratifying to scientists in general. However we must not "kill the goose that laid the golden egg". We must siphon some of the best scientific brains into the teaching profession. These are the scientists who are going to develop scientific thinking for tomorrow.

On the secondary school level a new program for the training of teachers has recently gone into effect in Indiana. Some of the members of this Academy have had a small part in setting up the science program. We are not altogether satisfied with our product but it is an honest attempt to furnish better science teachers to the secondary schools of Indiana. We think our secondary science teachers in the future will have a better academic background than those trained under past programs. We feel that these young teachers should acquire more than a knowledge of how to teach science. We hope they will learn some science to teach.

Without further elaboration let me bring this rambling discussion to a conclusion by summarizing the problem involved together with some suggestions for meeting it.

1. There is a definite shortage of well trained science instructors on the college level and this shortage gives promise of being further aggravated in the next decade.

2. Graduate training in the past in the various sciences has been directed in the main toward specialization in the research field.

3. In order that a research project be carried to a successful conclusion the trend has been toward rather narrow specialization in a specific compartment of a highly specialized division of natural science.

4. Our experiences in the war just concluded have proved conclusively that scientific training is imperative in a well rounded educational program. We have also learned that our educational institutions in the past have not given young people adequate background training in the sciences for military or industrial needs.

5. Colleges and even the better high schools are requiring graduate degrees for science instructors. These graduate degrees should be in subject matter fields and should be somewhat more comprehensive than degrees now offered in the sciences directed in the main toward research in a narrow specialized field.

6. The new trend toward general education is becoming more popular and science instructors engaged in this program are going to need comprehensive training in broad subject matter areas.

7. Willingly or not science is going to be compelled to assume some social and moral responsibility for scientific discoveries and inventions. The present world wide controversy concerning atomic energy has brought this issue clearly into the foreground.

8. Since some fifty per cent of our future Ph.D.'s in the sciences will in all probability enter the field of college teaching it would appear that science graduate schools should recognize this fact and take appropriate steps to direct a good part of the graduate training for higher degrees toward making well informed and broad minded science instructors.

9. Our future scientists are to be found among the thousands of young people now begging for admission to our colleges and universities. These young people deserve the best instruction that science can offer. It is neither right nor smart for Science departments to neglect these sources of potential strength by turning them over to poorly trained or indifferent instructors.

10. If science graduate schools consider that good science instruction is an important part of scientific growth it is logical to assume that the problem of supplying well trained science instructors for the colleges and universities should be attacked in a thoroughly scientific way. Future instructors should be selected early in their graduate careers by appropriate aptitude examinations. Serious study should be given to the kind of graduate training necessary for specific in-

struction in a given science field. If experience and sound judgment indicate that narrow departmental boundaries should be crossed to achieve most desirable results, ways and means should be found for doing this without in any way lowering standards or cheapening the degrees.

11. Teaching science in the colleges and universities should be considered on a par with scientific research by university administrators and science department heads, Rewards by promotion in rank and salary increases should be given for superior science instruction and time should be alloted for science instructors to carry on research of both a productive and professional nature.

12. The teaching profession in general and science teachers in particular long for the time when their profession will be accorded the respect now enjoyed by the medical profession and the research scientist. To attain this end science and those of us engaged in scientific pursuits will need to muster our best efforts. I believe that science teaching as a profession will become respected just as soon as it becomes respectable. To attain respectability superior college science teachers as well as superior physicians, superior engineers, and indeed superior cucumbers will have to be "grown on purpose".

ANTHROPOLOGY

Chairman: ERMINIE W. VOEGELIN, Indiana University

Mr. Arthur B. Carr, Indianapolis, was elected chairman of the section for 1948.

ABSTRACTS

A critique of some archaeological field methods. GLENN A. BLACK, Indiana Historical Society.—Articles have appeared recently in two reputable journals of wide circulation describing excavations at Tepexpan in the Valley of Mexico. Photographs accompanying the articles indicate that the excavations have not been made in such a manner as to give conclusive proof of the antiquity of the discoveries. A discussion of the proper field methods to be employed was given.

The origins of the Maya Indians. GEORGE K. NEUMANN, Indiana University.—In his recent volume, *The Ancient Maya,* Morley makes the statement that, ". . . all Maya speaking groups would seem to have sprung originally from the same ancestral stock." (p. 25) Comparison of measurements of various Maya groups collected by Star and others indicate the contrary. A later Central American variety of Indian probably subjugated earlier ones with a much wider distribution and absorbed them except for certain Maya tribes of the Guatemalan highlands.

A Persian bronze mirror case belonging to Shah-Nasir-al-Din. ALVAN C. EASTMAN, Evansville Public Museum.—The author showed pictures of a damascened bronze mirror case belonging to the Evansville Public Museum. Until recently it was described in the museum files as; "Spain, very old. Evidently belonging to the Moors. Once owned by a Sultan. Bought at the St. Louis Exposition in 1904." The author has had the inscription translated and found that it had been the property of the Shah of Persia, Nasir-al-Din who reigned from 1848 to 1896. He was the first Persian sovereign to be received at the English court. A description of his visit to Queen Victoria as given in her journal was read.

What makes museums "Tick". ARTHUR B. CARR, Indianapolis.—No longer a musty storehouse for antiquities today's museum is a real educational laboratory. The author discussed the importance of the displays in the large science museums, and health museums. The choice and arrangement of artifacts in exhibits of Anthropological material was discussed. In summary the author listed specific suggestions for the successful operation of a modern museum.

Stone artifacts and mid-western archaeology. PAUL H. GEBHARD, Indiana University.—A recent extensive study of stone artifacts in

North America brings to light some interesting distributional material on the presence of mid-western artifacts in other parts of North America.

North American Indian drama. BRUCE THOMAS, Indiana University.—The presence of true dramatic performances among the Indians north of Mexico was critically examined, and some positive evidence for the existence of such is adduced.

THE RELATIONSHIP BETWEEN A COASTAL ALGONKIN AND A KARANKAWA CRANIAL SERIES

CHARLES E. CLAUSER, Indiana University

This brief paper is an attempt to test Dixon's[1] contention that marginally distributed groups constitute remnants of the earlier migrants to the New World. In the past this contention generally has not been clearly demonstratable because of the lack of archaeologically datable crania from early horizons. All too frequently such material was pooled with later series, or if with contemporaneous ones, pools were made over so wide an area as to obscure local differences. At the suggestion of Professor Georg Neumann, two marginal series are used in this present comparison. One of these is a pooled series of crania from Long Island and Manhattan Island from the collection of the American Museum of Natural History; the other, a series of Karankawa crania from the Oso site, Neuces County, Texas. The latter are in the collection of the Department of Anthropology of the University of Texas. The New York Coast crania have been previously described by Hrdlicka;[2] the Texas coast crania, by Woodbury.[3] Both of these workers confined their studies to a brief list of metrical traits; therefore the collecting of additional measurements and observations was necessitated. These additional data were made personally by the writer on the New York Coast crania last summer,[4] while measurements and observations on the Texas coast series were kindly supplied by Professor Neumann.

In examining the measurements given in Hrdlicka's *Catalogue*, the writer found that a series of crania from Long Island and another from Manhattan Island, New York, were similar in many respects to the Karankawa. There were eleven crania in the Manhattan and six in the Long Island series. In order to have a larger series for statistical comparison with the Karankawa, the Long Island and Manhattan series were pooled. Hrdlicka previously has shown that they are identical.

The metrical comparison is made in Tables I and II. Here twenty-four measurements and fifteen indices are listed for each series. The statistical constants include the means and their probable errors (PeM), number of cases for each measurement (N), and the standard deviations (SD) with their probable errors (PeS). In the last two columns are listed the differences between the means of the two series (D) and

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[1] Roland B. Dixion, *The Racial History of Man* (New York: Charles Scribner's Sons, 1923), p. 398.

[2] Ales Hrdlicka, *Catalogue of Human Crania in the United States National Museum Collections* (Washington: United States Government Printing Office, 1927), pp. 18-19.

[3] G. Woodbury and E. Woodbury, "Prehistoric Skeletal Remains from the Texas Coast," *Medallion Papers,* No. 18 (Gila Pueblo, Globe, Ariz.).

[4] In this place I would like to express my indebtedness to Dr. Harry Shapiro of the American Museum of Natural History for help in locating eleven of the seventeen crania described by Hrdlicka.

TABLE I. Comparison of Measurements

	Karankawa					New York Coast						
	Mean	PeM	N	SD	PeS	Mean	PeM	N	SD	PeS	D	3PED
Cranial module	155.04	± .81	12	4.18	± .58	157.48	± .55	10	2.57	± .39	2.44	2.94
Glabello-occipital length	189.28	±1.26	18	7.92	± .75	191.91	± .75	11	3.68	± .53	2.63	4.44
Maximum breadth	133.50	± .69	18	4.34	± .49	137.59	± .66	10	3.08	± .46	4.09	3.10*
Minimum Frontal breadth	92.20	±1.07	15	6.17	± .79	95.82	± .57	11	2.80	± .40	3.62	3.64
Basion-bregma height	140.42	± .83	12	4.27	± .59	140.00	± .97	11	4.79	± .69	.42	3.81
Cranial Base length	102.50	±1.90	6	6.89	±1.34	103.90	±1.01	10	4.74	± .71	1.40	6.45
Total Facial height	128.30		3			118.33	±2.00	6	7.43	±1.45	9.97	*
Upper Facial height	78.00	± .63	5	2.10	± .45	72.89	± .98	9	4.36	± .69	4.17	3.34*
Total Facial breadth	134.16	± .76	12	4.95	± .68	131.37	±1.42	8	5.96	±1.00	2.79	4.83
Midfacial breadth	98.00		3			95.00	± .89	9	3.97	± .63	3.00	
Subtense to Inter-orbital breadth	19.54	± .52	11	2.54	± .37	17.44	± .33	9	1.48	± .23	2.10	1.85*
Inter-orbital breadth	96.80	± .63	14	3.50	± .35	97.78	± .85	9	3.80	± .60	1.07	4.17
Biorbital breadth	96.71	±1.90	7	7.56	±1.36	95.33	±1.03	9	4.60	± .73	1.38	6.48
Ant. interorbital breadth	19.90	± .26	10	1.23	± .18	19.30	± .46	10	2.17	± .33	.60	1.58
Nasal breadth	25.22	± .41	9	1.83	± .29	25.40	± .41	10	1.94	± .29	.82	1.73
Nasal height	56.70	± .59	5	1.95	± .42	52.10	± .79	10	3.70	± .59	4.05	2.86
Dacryal chord	22.50	± .08	5	.28	± .06	20.38	± .25	8	1.03	± .17	2.10	.20*
Dacryal subtense	13.04	± .40	5	1.67	± .36	11.83	± .59	6	2.12	± .41	1.18	2.14
Left Orbital height	33.60	± .38	9	1.70	± .27	32.60	± .26	10	1.20	± .18	1.00	1.73
Left Orbital breadth	41.13	± .32	8	1.37	± .23	42.60	± .30	10	1.41	± .21	1.47	1.31*
Maxillo-alveolar breadth	64.60	±1.11	6	4.08	± .79	64.60	± .70	10	3.29	± .49	0.00	3.93
Maxillo-alveolar length	56.60	± .99	5	3.28	± .69	51.44	± .79	9	3.52	± .56	5.16	3.80*
Left Orbital breadth, (d)	39.90	± .70	6	2.55	± .49	38.56	± .47	9	1.63	± .26	1.34	2.53
Bicondylar breadth	120.00	±1.50	4	4.40	±1.05	121.17	±2.25	6	8.17	±1.59	1.17	8.10
Mandibular length	109.66		3			112.17	±1.70	6	6.2	±1.21	1.51	

* Denotes a significant difference.

TABLE II. Comparison of Indices

	Karankawa					New York Coast						
	Mean	PeM	N	SD	PeS	Mean	PeM	N	SD	PeS	D	3PED
Cranial	70.66	± .62	18	3.91	± .44	71.62†	± .37	17	2.24	± .26	.96	2.17
Length-height	73.77	± .46	12	2.38	± .33	73.04†	± .42	16	2.46	± .29	.73	1.16
Breadth-height	104.71	± .60	12	3.09	± .43	101.76†	± .29	16	1.74	± .21	2.95	1.99*
Trans. Fronto-parito	69.30	± .91	15	5.24	± .65	68.21	± .46	10	2.17	± .33	1.09	3.06
Total Facial	97.39		3			90.07	±1.10	6	4.01	± .78	7.32	*
Upper Facial	58.99	± .71	5	2.37	± .50	54.86	± .44	11	2.17	± .31	4.13	2.51*
Midfacial	78.58		3			76.61	± .74	9	3.28	± .52	1.97	
Zygo-frontal	68.11	±1.07	9	4.75	± .76	72.19	± .93	8	3.90	± .66	4.08	4.23
Facial-flatness	20.13	± .50	11	2.47	± .36	17.83	± .39	9	1.76	± .28	2.30	1.19*
Anterior Interorbital	19.96	± .23	6	.82	± .16	19.79	± .29	9	1.30	± .21	.17	1.11
Left Orbital, (mf)	81.89	±1.17	7	4.60	± .83	76.04	± .74	10	3.47	± .52	5.85	4.14*
Left Orbital, (d)	85.02	±1.14	5	3.74	± .80	83.40	±1.15	9	5.12	± .81	1.62	4.83
Nasal	44.26	±1.03	5	3.40	± .76	46.43	± .71	15	3.50	± .50	2.17	3.75
Nasal Root height	59.58	±2.66	4	7.89	±1.89	54.49	±1.85	6	6.71	±1.31	5.11	9.69
Maxillo-alveolar	114.90	±1.66	5	5.50	±1.17	125.46	±1.79	9	7.94	±1.26	10.60	7.30*

* Denotes a significant difference.

† From Ales Hrdlicka, *Catalogue of Human Crania in the United States National Museum Collections* (Washington: United States Government Printing Office, 1927), pp. 18-19.

three times the probable error of the difference (3PED). If three times the probable error of the difference (3PED) exceeds the difference between the two means (D), it is almost certain that the differences are of statistical significance.

Nine of the twenty-four measurements compared showed such a statistically significant difference. These are as follows: maximum breadth, total facial height, upper facial height, midfacial breadth, subtense to interior orbital breadth, nasal height, dacryal cord, left orbital breadth, and maxillo-alveolar length. The most important difference between the two series is in facial height. The crania from Texas average approximately ten millimeters greater in total and about half that amount in upper facial height than those of New York. The average difference in midfacial breadth is only three millimeters. This might not prove to be of significance if more cases were available. It also should be noted that if dacryon instead of maxillofrontale is used as the terminal for orbital breadth, the difference is not significant. Although the differences in maximum cranial breadth and nasal height are real ones, they are not reflected in the cranial and nasal indices.

Both series are dolichocranial; high vaulted; narrow faced; although the faces of the Karankawa are considerably higher; mesoconch in orbital proportions; and leptorrhine; and like most American Indians, on the border of, or brachyuranic.

TABLE III. Comparison of Observations of Vault

	Karanka	New York Coast
Muscularity	sm. 1, med. 10, pron. 7	sm. 0, med. 10, pron. 1
Form	ellipsoid 9, ovoid 9	ovoid 4, pentagonoid 2, rhomboid 2
Brow ridge size	sm. 1, med. 6, large 9, v. large 2	sm. 2, med. 8, large 1, v. large 0
Glabeller prom.	sm. 2, med. 7, large 8, v. large 1	sm. 1, med. 7, large 3, v. large 0
Frontal slope	med. 6, pron. 12	sl. 4, med. 6, pron. 1
Frontal bosses	sm. 18, med. 0	sm. 9, med. 2
Median crest	none 1, sm. 7, med. 5, large 5	none 5, sm. 6, med. 0, large 0
Breadth	narrow 16, med. 2	narrow 1, med. 10
Sagittal elevation	abs. 2, sl. 6, med. 9, large 0, v. large 1	abs. 0, sl. 7, med. 4, large 0 v. large 0
Parietal bosses	sm. 9, med. 9, large 0	sm. 5, med. 6, large O
Lamboid flattening	abs. 2, sl. 6, med. 8, pron. 2	abs. 0, sl. 2, med. 7, pron. 2
Occipital curve	sl. 1, med. 7, pron. 10	sl. 0, med. 5, pron. 6
Temporal fullness	flat 13, sl. 4	flat 6, sl. 5
Mastoid size	sm. 0, med. 5, large 0, v. large 10	sm. 4, med. 7, large 0, v. large 0
Styloid process	sm. 13, med. 0, large 0	sm. 1, med. 1, large 1
Mandibular fossa	shallow 1, med. 4, deep 13	shallow 1, med. 9, deep 0
Tympanic plate	thin 12, med. 4, thick 0	thin 4, med. 3, thick 3

TABLE IV. Comparison of Observations of Face

	Karankawa	New York Coast
ORBITS		
Shape	oblong 2, rhomboid 0, ellipse 0, square 14	oblong 6, rhomboid 2, ellipse 2 square 0
Inclination	none 1, sm. 8, med. 9	none 0, sm. 7, med. 3
CHEEK REGION		
Size of zygomatic	sm. 0, med. 10, large 1	sm. 1, med. 8, large 1
Suborbital fossa	abs. 0, sl. 7, med. 1, deep 0	abs. 2, sl. 4, med. 0, deep 3
Lateral projection of zygomatics	sl. 1, med. 9, pron. 1	sl. 0, med. 9, pron. 1
Anterior projection of zygomatics	sl. 3, med. 8, pron. 0	sl. 1, med. 9, pron. 0
NASAL REGION		
Nasion depression	abs. 0, sl. 5, med. 10, deep 0	abs. 0, sl. 5, med. 4, deep 0
Nasal root height	low 0, med. 13, high 1	low 4, med. 6, high 0
Nasal root breadth	narrow 6, med. 9, wide 0	narrow 5, med. 5, wide 0
Nasal bridge height	low 0, med. 2, high 5	low 0, med. 3, high 2
Nasal bridge breadth	narrow 3, med. 4, wide 0	narrow 3, med. 2 wide 0
Nasal profile	straight 0, sl. concavo-convex 8	straight 1, sl. concavo-convex 6
Anterior nasal spine	abs. 0, sm. 6, med. 3, large 0	abs. 1, sm. 0, med. 4, large 1
Nasal sills	abs. 0, dull 4, med. 5, sharp 0	abs. 0, dull 2, med. 6, sharp 0
FACE		
Face size	med.	med.
Midfacial prognathism	abs. 9, sl. 0, med. 0, pron. 0	abs. 2, sl. 6, med. 1, pron. 0
Alveolar prognathism	abs. 0, sl. 8, med. 1, pron. 0	abs. 1, sl. 5, med. 1, pron. 0
Total prognathism	abs. 1, sl. 8, med. 0, pron. 0	abs. 1, sl. 7, med. 1, pron. 0
PALATE		
Palate shape	parabolic 9	parabolic 10
Palatine torus	abs. 8, sm. 0, med. 1	abs. 4, sm. 5, med. 1
MANDIBLE		
Size	sm. 0, med. 3, large 3, v. large 1	sm. 1, med. 5, large 2, v. large 0
Chin form	median 1, bilateral 5, medio-bilateral 1	Median 1, bilateral 7
Chin projection	negative 0, neutral 4, sm. 2, med. 1, large 0	negative 0, neutral 1, sm. 5, med. 2, large 0
Gonial angles eversion	none 1, sm. 3, med. 1, none 0, sm. 7, med. 1, pron. 0	pron. 1

In making morphological observations of the New York Coast crania, the list of traits are the same as those which appear on the Harvard sheets, with certain modifications by Neumann. Of forty-one traits compared, the modes of twenty-nine traits were the same for both series; of the remaining twelve, some of the differences may be due to the personal factor. However, in case of frontal slope, median frontal cresting breadth of the frontal, and shape of orbits, real differences appear to exist.

The New York Coast series in general can be characterized morphologically as ovoid to pentagonoid in form, with medium developed brow ridges, medium frontal slope, submedium frontal and medium lambdoid flattening, pronounced occipital curvature, oblong to rhomboid orbits, zygomatic bones of only medium size with medium amount of lateral and anterior projection, medium wide and medium to low root height, medium high nasal bridge, medium face size, bilateral neutral chin, and a small amount of gonial eversion.

The Karankawa crania similarly can be described on the average as ovoid to ellipsoid in form, with large to medium developed brow ridges, pronounced frontal slope, submedium frontal and medium sagittal cresting, narrow foreheads, small to medium parietal eminences, medium lambdoid flattening, pronounced occipital curvature, low placed occiput, square orbits, zygomatic bones of only medium size with a medium amount of lateral and anterior projection, a medium wide and medium size with a medium amount of lateral and anterior projection, a medium wide and medium high nasal root, high nasal bridge, medium face size, bilateral neutral chin, and a small amount of gonial eversion.

In concluding, it may be suggested (1) that a breaking down of the widely distributed Algonkin type of Hrdlicka may be justified both metrically and morphologically, (2) that on a geographic basis the marginal eastern dolichocephals may represent an older type that resisted complete absorption by the later coming Algonkquian-speaking groups, and (3) that these coastal long-heads are closely related to other peripheral groups, such as the Karankawa of the Texas coast.

Hupa Birth Rites

EDITH TAYLOR, Indiana University

Introduction. The Hupa are a small Athabascan-speaking tribe living in Northwestern California. They live in a broad, sunny valley stretching about eight miles along the Trinity River. The yearly salmon run and the abundant acorn crop are their main sources of food. Their culture has been well described by Pliny E. Goddard in *Life and Culture of the Hupa*, published in 1903.[1] The material given here was collected during two field trips, in 1945 and 1946, and a brief visit this summer.[2]

Pregnancy and Prenatal Influences. Pregnancy is revealed to a Hupa woman only by the cessation of the menses, there being no other recognized signs. Immediately precautions are taken for the benefit of the developing child. The prospective mother is especially careful in her diet. She eats sparingly in order to keep the foetus small and to insure a quick and easy delivery. If this is her first child a young mother is abstemious to the point that frequently she starves herself to avoid having a big baby. No meat is eaten as this is considered fattening. Acorn mush—"because it will make lots of milk"—and dried salmon are her principal nourishment. She is also cautioned against drinking too much water because it will cause a hard birth and might also result in loss of hair for the infant.

A woman continues to work throughout her pregnancy except for short periods when work is impossible such as when spells of nausea and giddiness overcome her. Not only is laziness in women ridiculed by the Hupa but work, it is believed, keeps the foetus small. However, heavy work is lessened as she approaches the end of her term.

Medicines are constantly employed throughout pregnancy with a view also of keeping the developing child small. Formulas are recited—either by the formulist or by the pregnant woman herself[3]—over various growing young shrubs. The tender shoots are then picked and chewed and the juice, which is swallowed, is thought to assure easy delivery.[4]

No attempt is made to influence the sex of the child because both male and female children are equally desired. Nor do the Hupa have any methods of predicting the sex of the foetus. There are no beliefs regarding prenatal influences. The foetus is unaffected by the mother staring or looking at any unpleasant object.

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[1] Additional facts may be found in Kroeber 1925 and Driver 1939.

[2] Goddard's and Driver's statements about childbirth were checked with informants and in most instances were corroborated. Disagreements are noted in subsequent footnotes.

[3] Goddard 1903, p. 50 states that the prospective mother during the first four months of the term made medicine for herself.

[4] Goddard 1904, p. 275-7 gives two formulas.

The father is subject to no special rites or food taboos during his wife's pregnancy other than continence. As soon as pregnancy is ascertained, sexual relations cease because it is believed to injure the foetus and intercourse is not resumed until the child is able to walk.[5]

If the woman dies during pregnancy, the foetus is removed as the Hupa consider it "not right to leave it inside her." Should the foetus still be alive, a cord is tied tightly about the deceased mother's abdomen to kill the unborn child which is then removed. Such a foetus, as well as a miscarriage may not be buried inside the cemetery but only at its edge.

Birth. At the end of the nine months and with the onset of labor pains the woman goes into the dwelling house.[6] She calls or sends for "a woman who knows about such things" to help her in the delivery. She sits with a hide or a blanket beneath her so that the newborn baby will not touch the earthern floor. During her travail, the woman grips a leather strap suspended from the roof beams. She also may be given a slender stick upon which to clench her teeth during labor. This helps to keep her from crying aloud and thus spares her from subsequent teasing and ridiculing, as it is considered a sign of weakness to cry out during labor.

Should the birth be difficult, medicine is brewed by the midwife (not a doctor). Herbs are boiled in water and formulas recited during the preparation. Some of these decoctions are taken internally; others are massaged on the mother's body.

After delivery the navel cord is cut off short—in the old days with a white stone knife—and the end attached to the newborn infant is tied with a leaf.[7] The afterbirth is disposed of without any special observances and is simply burried outside the village. In the event of a stillbirth, the dead child is buried outside the cemetery.

A caul is considered "lucky" and although it is removed very carefully it is buried with the afterbirth. Physical abnormalties are known but occur rarely. Such an infant is kept, given as good care as possible and "sometimes, when it gets older an Indian doctor may be called in." Deformities, including even minor ones as birthmarks, are not attributed to any mystical prenatal influences but are believed "to be inherited." Infanticide is not practised. Twin births are known but the Hupa have no special attitude pertaining to them; they are

[5] Goddard 1903, p. 52 states that "the grandmother, if one lives in the house, ties a small dentalium shell to the ankle of the baby. This remains until the mother's relations with her husband are resumed. The mother is taught that ill luck will come to the child if the shell be allowed to remain longer. It is therefore a sign to the old people that the law, which separates a nursing mother from her husband during the first year is being kept."

Driver 1939, p. 350 states that continence lasts 24 months after birth.

[6] Goddard 1903, p. 51 says that birth took place in the menstrual hut. This hut seems to have disappeared early and is not remembered by any of the present day Hupa.

Driver 1939, p. 348 says birth took place in dwelling house.

[7] Driver 1939, p. 349. Driver's informants state that a buckskin string is used. One of them said a vegetable fibre string also is employed.

welcomed and treated as other children. Triplets are unknown.[8] Mothers frequently die in childbirth and stillbirths and miscarriages are also common.

Post-Delivery Customs—Mother's role. After delivery the mother lies down in a shallow pit. This pit, which is dug into the earth floor at one corner of the house, is lined with heated stones and then covered with either damp wormwood or wet sand. The resulting steam is believed to hasten the mother's recovery and to heal all birth tears and injuries. This "steaming" process continues for ten days, during which time the mother's needs are attended to by a kinswoman or neighbor. At the end of ten days she resumes her daily routine. However, she continues to eat apart from her family for 40 days if she gave birth to a boy and 50 days for a baby girl.[9] The new mother refrains from drinking cold water and eating fresh meat or fresh salmon for varying lengths of time. She is, however, encouraged to eat acorn mush.

Father's role. The father, whose only contribution to the welfare of his expected child was continence, leaves the dwelling house at the time of delivery. If this is his first child he goes up a mountain alone, builds a fire of green pine boughs and, smoking himself, prays for the well-being of his newborn infant. He does not do this, however, for subsequent offspring.

The father eats alone for the first few days after the birth of his child and avoids meat, fresh salmon and drinks thin acorn soup instead of cold water.

During the first five nights he stands guard outside the dwelling house in order to "chase the Indian devil away so it will not witch his child."[10]

The Infant. As soon as it is born, the infant is held upside down by the feet and shaken and patted by the midwife until a deep breath of air is initiated. The baby is then bathed by the midwife as it lies in her lap, the warm water being gently sprinkled and spread by hand over its body. The infant is next placed in a small, flat, openwork basketry tray (kaitel) and held over a steaming pot of herbs and hot water. These herbs are procured from a doctor. During the first ten days of its life the infant is frequently steamed and numerous formulas

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[8] Driver 1939, p. 350 says that twins are feared and twinning is considered contagious disease. For the neighboring Yurok, Kroeber 1925, p. 45 states that if twins of opposite sexes were born, the Yurok smother one of the pair, usually the girl. They had a dread of such births, which they explain on the ground that if the twins lived they might be incestuous. Boy twins were believed to quarrel all their lives, but were spared. Once triplets were reported among the Yurok, which caused much excitement and talk of killing them as it portended sickness.

[9] Goddard 1903, p. 51 says that for a miscarriage the restrictions apply for 60 days.

[10] Goddard 1903, p. 51 says that the infant's first 10 days of life were subject to attacks from evil spirits, and the fifth was thought to be especially dangerous.

are recited to protect it from all danger, to give it strength and to ensure a long life.[11] The infant suffers a great deal during the ten day medicine-making period and many are said to die as a result of the "cooking" treatment.

For the first few days the newborn baby is not put to the breast but is fed a thin gruel of mashed pine nuts and water. Only after the mother has eliminated the colostrum from her breasts is the child given mother's milk. Thereafter, however, the baby is nursed whenever it shown signs of hunger and is allowed to have as much milk as it wants. Nursing is continued until the child walks.

If the mother should die in childbirth, every effort is made to find a wet nurse who will take over the feeding of the infant. The pine-nut soup, meanwhile, is continued. Mothers without milk are rare, if not unknown, because according to a Hupa adage "acorn mush makes lots of milk."

The navel cord, which dries and falls off the baby in two or three days, is put in a little bag made from the tip of a bear's ear and thus is hung about the infant's neck until the father takes it up the mountain.[12] The father splits a young pine tree and places the dried navel cord inside and binds the tree back together. The fate of this pine is carefully observed by the family for it is believed "as the tree grows so will grow the child." The Hupa avoid cutting such trees for firewood.

Friends and relatives, visiting the mother and new-born infant during this ten day period, bring presents such as a baby-basket or a fine buckskin. The gifts are given to the child, not to the mother.

No name is given the child at this time, it is simply called "baby", "little one" or some term of endearment.

On the tenth day the baby, wrapped in a soft buckskin, is laced into the sitting cradle (xea-kai). Here it remains—save for brief bathing and exercise periods—until it can walk alone. Also on the tenth day the infant's hair is singed with a hot coal.[13] The odor of his burnt hair brings him to the attention of the dieties who previously were unaware of the child's existence. Thus, officially begins the career of a new Hupa individual.

Bibliography

Driver, Harold E. 1939. *Culture element distributions:* X Northwest California University of California Anthropological Records 1:6 pp. 348—351.

Drucker, Philip. 1937. *The Tolowa and their southwest Oregon kin.* University of California Publications in American Archaeology and Ethnology v. 36, no. 4, pp. 221—300.

Erikson, E. H. 1943. *Observations on the Yurok: childhood and world image.* University of California Publications in American Archaeology and Ethnology v. 35, no. 10, pp. 257—302.

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[11] Goddard 1904, pp. 286-298 gives three formulas, one to make the child grow fast, one to make it grow strong, and one to cause it to reach old age. These medicines were made on different days of the ten.

[12] Driver 1939, p. 349. Driver's two informants disagreed between themselves on the disposal of the naval cord.

[13] Goddard 1903, p. 51 says "the infant's hair was cut off and put in the fire."

Goddard, Pliny Earle. 1903. *Life and Culture of the Hupa.* University of California Publications in American Archaeology and Ethnology v. 1, no. 1, pp. 1-88.

1904. *Hupa Texts.* University of California Publications in American Archaeology and Ethnology v. 1, no. 2, pp. 89—368.

Kroeber, Alfred L. 1925. *Handbook of the Indians of California.* Bulletin of the Bureau of American Ethnology, no. 78, pp. 128—41.

Wallace, William J. 1947. "Hupa Child-Training: a Study in Primitive Education" in *Educational Administration and Supervision* v. 33, no. 1 Jan., pp. 13—25.

A Bone Flute from Angel Site

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During the 1947 digging season at Angel Site, Vanderburgh county, Indiana, a perfect bone flute was uncovered. In previous years, fragmentary flutes have been found at this site but, until now, none in perfect condition.

Before I describe this flute, I would like to state that in American archaeology, the terms "flute" and "flagolet" have been used interchangable, with a majority of workers tending to favor the term "flute". This is regrettable for, in a technical sense, flagolet more readily describes the instruments in question. We think of a flute as an instrument that is blown while held with its long axis at right angles to the lips, and a flagolet as one that is blown with the long axis in line with the lips. The Indian "flute", insofar as I can determine, is blown with the long axis in line with the lips and thus, would technically be a flagolet. Since the more widely accepted name now in use is "flute", I shall refer to these instruments as flutes throughout this paper.

The Angel Site flute was uncovered in the village debris at the 1.2′ to 1.6′ level. The bone from which it was fashioned has been tentatively identified as the leg bone of a large wading bird, one of the herons or cranes. This flute has a total length of four and one-eighth inches with a mean outside diameter of five-sixteenths of an inch and a mean inside diameter of four-sixteenths of an inch. Along its length are seven perforations which average five-sixtyfourths of an inch in diameter and one-fourth inch from the center of one perforation to the center of the adjacent perforation. Five of these perforations are oval and two are round. The oval perforations vary so little from the round that I feel justified in terming all perforations round.

The tonal qualities of this specimen fall in the second octave above middle "C" and approach the pentatonic scale. This is probably accidental, for primitive instruments are made to no set standard and the tones produced vary with each instrument. This is corroborated by Roberts who states:

> "even among primitive tribes where instruments such as flutes capable of producing several tones are common, it is a matter of repeated observation that the instruments vary considerably from speciman to speciman in actual scales achieved." (1)

Flutes of this type have been found at many sites throughout the country. Hooton and Willoughby describe a find made at the Madisonville Ohio site in great detail. They say:

> "About twenty of the flute-like objects of the type shown in plate 15,d, made from the long bones of birds, were found during the explorations by the Museum. They are mostly small, and judging from the unbroken specimans recovered the number of finger holes range from five to nine, the usual number being five or six. The holes are commenly about one-half inch apart, but in one speciman the centers of the perforations are placed about one-fourth inch from each other, too near, it would seem, for its successful manipulation by the fingers of an adult." (2).

This description, in nearly all respects, describes the Angel Site flute.

Other bone flutes are reported from the excavations at Pecos (3), from among the Caddo (4), from the Archaic and Late Prehistoric patterns of New York State (5), and from the Fort Ancient aspect of Ohio and West Virginia (6). These flutes are in most respects similar to the Angel Site flute.

Another type of flute found in North America is that made of reed or cedar. Archaeologically, in this area, only bone flutes are found; and I mention flutes constructed of other material only because they were, in all probability, a part of the cultures that produced the bone flutes.

Bibliography

1. Roberts, Helen H., Am. Anthro. **34**:81.
2. Hooton, Earnest A., and Chas. C. Willoughby, Papers of the Peabody Mus. of Am. Arch. and Eth. Vol 8, No. 1
3. Peabody, Chas., Am. Anthro. **19**:30-33.
4. Swanton, J. R., Bur. Am. Eth., 42nd. An. Rep., p. 9
5. Ritchie, Wm. A., The Pre-Iroquoian Occupations of New York State, Rochester, 1944.
6. Griffin, James Bennett, the Fort Ancient Aspect, Ann Arbor, 1943, p. 144.

Worked Deer Astragali from the Angel Site

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At last year's meeting Glenn A. Black called attention to the worked deer astragali found at the Angel Site, in Vanderburgh County (1). The present paper is a restatement of what he said, plus the results of tests I made with the astragali at Mr. Black's suggestion.

The worked astragali are ankle bones from the deer and wapiti which have been cut and ground into rectangular shapes. One hundred and thirteen of these have been found at the Angel Site. Four of them were made from the astragali of the wapiti or elk (Cervus canadensis), while the rest come from the Virginia deer (Odocoileus virginianus).

During historical times the Pomo Indians of California made dice out of the ankle bones of deer, (2) while the Papago Indians of Arizona did likewise with the ankle bones of bison. (3) The worked astragali found at the Angel Site were probably used for the same purpose.

Astragali dice are also found in Middle Mississippi sites, in Tennessee (4) and Arkansas (5). The Indiana Historical Society has a specimen from the Mouth of the Wabash Site, (6) and a possible specimen is reported from the Wheeler Basin in northern Alabama (7).

It was suspected that some of the dice from the Angel Site were cut so that one side—the pitted side—would land uppermost more often than the others. It was to see whether this suspicion would be borne out that I undertook tests on some of these astragali. I chose seven dice that showed varying degrees of alteration and made two hundred throws with each one of them. I threw them as in the following description of the dice game called *tanwan*, played by the Papago Indians:

"The game is played by two persons, who sit facing each other, four or five feet apart. The bone is twirled into the air out of the thumb and forefinger, the back of the hand being held upward. The position in which it falls on the ground controls the count in the game. So long as the player succeeds in throwing the pitted side, or cow hoof, as it is called, upward he retains possession of the bone, and with each throw wins one bean from a prearranged number equally divided between the players. The sides do not count in the play, and the thrower may play again and again without forfeiting the bone until he throws the flat side, opposite the cow hoof, upward, when the bone goes to his opponent to throw, with the same conditions. The winning of the entire number of an opponent's counters constitutes a game won." (3)

Although the dice have six faces, the two ends were not considered in my figures since they came up only very infrequently on but two of the seven dice. Therefore, I considered 25% the norm for one of the other four faces to come up. An average of the seven cut dice showed that the pitted side came up most often, 30.4% of the time, or 5.4% above the norm. The flat side opposite occurred 2.3% above the norm, and the other two sides 3% to 4.7% below the norm. The more worked a die was the closer did it conform to the norm.

I then made similar tests with five astragali which showed no evidence of being altered. The pitted side was 15.9% above the norm, the flat side opposite was 7.3% above, and the other two sides were 10.2% and 13% below the norm.

Even though the pitted sides of the worked astragali came up more than thirty per cent of the time, the pitted sides of the unworked astragali came up more than ten per cent more often. Therefore, it would seem as if the inhabitants of the Angel Site did not make a conscious effort to make dishonest dice for use in their games.

Bibliography

1. Black, Glenn A. *Some Rare or New Middle Mississippi Traits.* Manuscript.
2. Culin, Stewart. Bur. Am. Eth., 24th An. Rep. Washington, 1907, p. 135.
3. Id., p. 148.
4. Letter from Madeline Kneberg to Glenn A. Black, June, 1946.
5. Letter from Harry J. Lemley to Glenn A. Black, July, 1946.
6. Cut bison astragalus found with Burial 81 by Cliff Anderson at Mouth of the Wabash Site. I.H.S. Catalogue No. 38/162 and Andover Catalogue No. 15186.
7. Webb, William S. Bur. Am. Eth., Bull. 122. Washington, 1939, p. 33.

The Incidence of Ear Exostoses in the Hopewell People of the Illinois Valley

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It was observed almost two decades ago by Dr. Don Dickson of Lewistown, Illinois, that in the Illinois valley the existence of ear exostoses was almost entirely limited to crania from Hopewellian mounds. Recently the senior author measured and collected morphological observations on all available Hopewellian crania and included this anomaly in his list of observations. In the present paper this data, as well as that from a number of non-Hopewellian series is analyzed and discussed by both authors.

The ear exostoses, which form the subject of this paper are bony growths usually located on the posterior superior margin of the tympanic ring. In some cases—not observed in the series discussed here—this thickening may be located at the anterior upper termination of the open ring. Often it is large enough to occlude most of the external auditory meatus. Most of them have a solid eburnized appearance unlike the less dense bone of the rest of the ring. As a whole this anomaly is rather rare, its exact cause and nature are not known.

According to Hrdlicka,[1] who collected extensive data on this subject, the incidence of ear exostoses varies considerably according to racial groups. He found it absent in 267 skulls of African Negroes; relatively rare in Europeans, the anomaly being reported in only 1.1% in over 40,000 individuals; in less than 1% in native Australians; more frequent in Melanesians, in 10% of a series of 20 skulls; and most frequent both in Polynesians—around 25.7% in a series of 167 skulls—and in some American Indian groups.

The data compiled by Hrdlicka on American Indian series is summarized in Table 1, according to the percentage of occurrence of exostoses in nineteen groups. Unfortunately these percentages are not of equal significance, for a high frequency of the anomaly in a small inbred group may be entirely obscured in the pooling of crania from a wide area or in a large series of crania from a circumscribed locality, but representing material from a number of archeological horizons. Nevertheless, the list includes a number of percentages that represent inbred family lines. This applies especially to the last three groups.

In order to indicate the true significance of the data, we present the series from the Illinois valley according to archeological populations as well as a pooled group in Table 2.

The time element is furthermore indicated by a chronological arrangement of these units—the earliest being at the bottom, the historic Illinois tribal data at the top of the table. The most obvious fact shown

[1] Hrdlicka, Ales. *Ear Exostoses.* Smithsonian Miscellaneous Collections, Vol. 93, No. 6, Publication No. 3296, 100 pp. Washington, D. C., 1935.

in Table 2 is, on the one hand, the absence of ear exostoses in three of the groups, and on the other, the relatively high incidence of the feature among crania from Hopewell mounds. In fact, this bony growth shows a more frequent occurrence among these Hopewellians than in any of the groups listed by Hrdlicka.

Table 3 shows an analysis of the Hopewellian material according to class, racial classification and artificial deformation, and Table 4 gives detailed information about each case. It is of considerable interest that the exostoses occur only in Hopewell skulls from the mounds; they

TABLE 1. Comparative Data on American Indian Series (Hrdlicka, 1935)

Group	Skulls	Skulls with exostoses	Per-cent
Northwest Coast (undeformed)	112	0	....
New England	64	0	....
Karankawa	18	0	....
Eskimo	1000	2	0.2
Vancouver Island (deformed)	260	5	1.9
Old Pueblo	500	12	2.4
California	816	38	4.7
North Dakota	29	2	6.9
Florida	395	35	8.9
Northeastern states	112	13	11.6
Tennessee and Ohio	459	71	15.5
Virginia	65	14	21.5
Louisiana	61	15	24.6
Northwest coast, Chinook	94	24	25.5
Arkansas	173	47	27.2
South Dakota	109	30	27.5
South Dakota, Mowbridge	76	23	30.3
Coahuila	22	7	31.8
Kentucky	90	29	32.2

TABLE 2. New Series from the Illinois Valley

Group	Skulls	Skulls with exostoses	Per cent
Kaskaskias (Iliniwek)	10	0	....
Maples Mills, Woodland	32	3	9.4
Spoon River, Middle Miss.	45	0	....
Hopewell, village graves	8	0	....
Hopewell, mounds	41	14	34.1
Black Sand, Early Woodland	8	0	....
Total: Illinois valley	144	17	11.8

are entirely lacking in individuals from graves along the bluffs which overlook the tumuli in the river bottom. In each of the eight instances the flexed burials from the village sites had typical Hopewellian potsherds in the grave fill. The only conclusion which can be drawn from this high incidence of exostoses is that the burials in the log tombs of the mounds represent a caste—a ruling group or priest class. And this assumption is strengthened by the profuse inclusion of grave goods of high artistic workmanship and the care that must have been lavished in burial arrangements.

When the skulls are classified according to morphological types the data is too meager to allow us to draw any specific conclusion. The exostoses are found in each of the three varieties, and perhaps most

TABLE 3. Incidence of Exostoses in Hopewellian Crania.

	Male present	Male absent	Female present	Female absent
Crania from mounds	11	18	3	9
Crania from graves	0	8	0	0
Otamid variety	2	5	0	3
Lenapid variety	3	16	3	4
Walcolid variety	1	2	0	0
Variety unknown	5	3	0	2
Undeformed crania	3	6	2	6
Deformed crania	6	9	1	2
Unobservable	2	11	0	1
Hopewellian totals	11	26	3	9

TABLE 4. Hopewellian Skulls with Ear Exostoses.

No.	Sex	Age	Variety	Deformation	Amount of Exostoses
A 4771	M	48	Otamid	....	Rt. and Lt. med.
F 60-4	F	47	Lenapid	undeformed	Bilaterial
F 188-11	M	46	Lenapid	....	Trace, bilateral
F 191-3	M	Adult	....	occip. def.	Rt. present, L. none
F 191-4	M	Adult	....	occip. def.	Rt. none, L. present
F 191-5	M	Adult	....	occip. def.	Rt. present, L. none
F 191-7	M	Adult	....	bifronto-occip. def.	Rt. small, L. small
F 191-12	F	45	Lenapid	occip. def.	Rt. small, L. large
F 191-13	M	46	Lenapid	none	Bilateral
Mn 9-2a	M	65	Otamid	undeformed	Bilateral, trace
Mn 9-8a	M	Adult	....	....	Med. size
Mn 9-12	M	40	Walcolid	deformed	Bilateral
P 477-3	M	Adult	Lenapid	deformed	Bilateral
P 478-1e	F	65	....	undeformed	Present in one side

frequently in skulls that have been classed as Lenapid (Sylvid or Algonkin type), but it must be kept in mind that this variety also seems to be the most commonly represented one. Another study definitely indicates that the more ancient Otamid variety continued into the Hopewellian period, but the individuals which seem to belong to this type may merely represent a resegregation in a number of morphological characteristics. The Walcolid variety (Centralid or Gulf type), which appears to indicate a late intrusion of a southern group into developed Hopewellian is represented by no more than 8% of the Hopewell population considered here.

A number of writers, who noted that ear exostoses may appear in high frequencies in American Indian crania with artificial deformation, have been inclined to attribute the abnormality to head deformation. Others have denied this, and Hrdlicka (p. 70) has definitely shown that the syndrome of these growths exists independently of cranial deformation, and that there exists many large series of greatly deformed skulls without a trace of exostoses. The data from the Illinois valley crania in Table 3 seems to substantiate this as the exostoses are found in 33% of the undeformed and in 39% of the deformed Hopewell crania. Piercing of the lobes of the ear, their extension, and the wearing of heavy ear ornaments have been thought to act as the exciting causes for the development of bony growths in the canal. We know that the Hopewell people from the Ohio mounds wore ear-spools and it is probable that the Hopewell people of the Illinois valley did the same, but so far no ear spools have been discovered in the tombs. But even if the wearing of ear-spools could be definitely correlated it is unlikely that this practice would be the only causative factor. In this connection it should be noted that European physicians have made the observation that the condition seems to be limited to people belonging to the economically more privileged classes—an observation that tends to point to some environmental causes as exciting factors in individuals in which there exists a predisposition to the formation of this anomaly.

A more likely explanation, which is also held by the writers, is that ear exostoses have an hereditary basis, that is, that there exists a predisposition for this thickening of the upper limits of the tympanic ring in some family-lines and that the high incidence of the exostoses is due to a combination of a highly inbred group with the predisposition and some external factor such as artificial deformation or the wearing of ear-spools.

The Girls' Puberty Rite of the Mohave

William J. Wallace, Indiana University

Introduction

The Mohave are a Yuman-speaking tribe living along the Colorado River where it forms the boundary between Arizona and California. They share with other river Yuman peoples a distinctive and specialized culture based upon agriculture and dominated by dream revelations and militarism.[1] The information on girls' puberty observances presented here was obtained from Mohave living at Needles, California, and on the reservation at Parker, Arizona.[2]

Puberty Observances

Menstruation does not come as a surprise to a Mohave girl because "her mother warns her that it is coming" and "not to be frightened because all women have it." At the onset of the menses she begins a four day period of seclusion, "sitting alone in the corner of her own house" and doing nothing.[3] She eats sparingly, mostly wheat mush or mesquite bean gruel, and eschews salt, meat, and fat for four days.[4] She drinks only warm water "because if she swallows cold water she will have a bad stomach."

The menstruant does not touch herself with her fingers; should she use them to touch her hair, "it will get all snarled and stay that way;" if she touches her face, "it will always have black marks on it." Instead she uses a scratching stick made from a piece of shredded arrowweed or from a mesquite twig. If she wishes to wipe her face she does so with a piece of soft willow bark. There are other restrictions on her actions as well; she must not paint her face because "if she does it will leave marks;" she must not look at her image in water or in a mirror or "she will become cross-eyed." The girl wears a specially prepared willow bark skirt designed to absorb most of the catamenial discharges, the remainder being taken up or wiped off with straw or bark upon which she sits. She does not wear a special menstrual belt.

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[1] Mohave culture is described by Kroeber 1902, 1925, and Curtis 1908. Drucker 1941 gives additional details.

[2] The fieldwork was financed by a grant from the Department of Anthropology, University of California.

[3] Kroeber 1925, p. 748 states that the girl was not confined. Drucker 1941, p. 141 indicates that she was.

[4] Kroeber 1925, p. 748 says that salt and cold water were avoided for 40 days. Drucker 1941, p. 142 records only 4 days. These disagreements with Kroeber's data probably indicate that some puberty customs have changed during the years between Kroeber's visit to the Mohave and that of Drucker and myself. Driver 1941, p. 59 notes a number of modifications in the Yuma girls' rite over a period of years and similar historical changes may also have occurred in the Mohave observances.

The menstruating girl remains alone for most of the day. Occasionally her mother and grandmother come in and talk with her, telling her "that she is a young lady and not a girl any more" and advising her "what a woman should do and should not do." Her behavior at this time is believed to affect her future character and disposition so the adolescent girl is careful to observe correct deportment. She must not "laugh out loud or act silly or she will grow up like that." Conversation is not prohibited but she should not "talk too much or she will talk and gossip all the time when she gets older."

Each night for four nights[5] the menstruant lies in a pit scooped out of the sand to a depth of six inches or a foot in one corner of the house. The pit is warmed by building a fire in it and scraping out the embers. Warm sand is heaped up around the girl and blankets are placed over her. This "roasting" is believed to be of therapeutic value and to contribute to the general physiological well-being of the pubescent. She has to lie on her stomach because "if she lies on one side her breast on that side will be longer" or, if she rests on her back, "she will have aches in her back when she has her first baby." Each morning and evening she is bathed with warm water. The menstruant does not go to the river to bathe because "if she steps in cold water she will have pains." Her mother also combs her hair each morning and, so that she she may have a clean head for the remainder of her life, delouses her and puts the lice in a small pot."[6]

The menstruating girl seldom goes outside except to relieve herself. When she does, another bark skirt is put on and she is "all wrapped up" in order to prevent exposure to cold. While outdoors she avoids meeting people. The concept of malignancy at puberty and menstruation, which is strongly developed in many North American tribes, is weak among the Mohave. A menstruant is shunned by men, particularly by hunters and warriors, but this is rather casual and there is no attempt to counteract any evil influence of the girl that is undergoing the rite. While walking in the brush the pubescent girl breaks off arrowweed twigs. This is said to "mean nothing."[7]

Dreams are of particular importance at the time of the first menses and the girl is told to remember as many of them as possible. Her sleep experiences are recounted to an older person who from them is able to foretell her future. There is no singing, dancing, or public ritual for adolescent girls: the whole rite is simple and private. The four day observances are concluded with a bath of sage leaves in warm water. The girl is "washed all over by her mother so that she will not stay in that period." She is then considered an adult and "does not expose herself anymore." Heretofore designated as "misahaija" (girl), she is now called "misahaija hacim" (girl menstruant).

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[5] Actually this is a variable period because "a girl has to lie there as long as she is bleeding."

[6] Drucker 1941, p. 143 states that the lice were put in an olla which was later placed in the river.

[7] Both Mohave men and women habitually snap off twigs while walking in the brush.

All the observances are repeated for the second and third menstrual periods.[8] For the fourth and subsequent ones, however restrictions are relaxed and the girl "can eat anything but meat— and just a little salt." After her fourth period a new status term is employed "misahaija hacim hacim" and the girl is considered ready for marriage though actual matrimony usually comes several years later.

Conclusion

The Mohave girls' puberty rite is on the whole relatively unimportant and unimpressive. Many of its elements such as the use of a scratching stick and the salt and cold water tabu are widespread North American Indian traits.[9] The rite aligns with those of southern California in "roasting" the girl but differs from the observances of most California tribes in being familial rather than public and lacking singing and dancing.[10] There are, as might be expected, many similarities in function and procedure between the Mohave girls' adolescent rite and those of other river Yuman tribes, although the Mohave rite is somewhat simpler.[11] Analogies with puberty observances of the Southwestern tribes, beyond a few widely distributed North American traits, are few.

Bibliography

Curtis, E. S. 1908. The North American Indian (Cambridge, The University Press) v. 2.

Devereux, George. 1937. Sexual Life of the Mohave Indians, Ph.D. thesis University of California (Berkeley).

Driver, H. E. 1941. Girls' puberty rites in western North America, University of California Anthropological Records v. 6, no. 2 (Berkeley).

Drucker, Philip. 1941. Culture element distributions XVII Yuman-Piman University of California Anthropological Records v. 6, no. 3 (Berkeley).

Du Bois, Cora. 1932. Girls' adolescence observances in North America Ph.D. thesis University of California (Berkeley).

Forde, C. Darryl. 1931. Ethnography of the Yuma Indians University of California Publications in American Archaeology and Ethnology v. 28, no. 4 (Berkeley).

Gifford, E. W. 1933. The Cocopa University of California Publications in American Archaeology and Ethnology v. 31 (Berkeley).

———— 1940. Culture element distributions XII Apache-Pueblo University of California Anthropological Records v. 4, no. 1 (Berkeley).

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[8] According to Kroeber 1925, p. 748 restrictions were observed for the first six periods. Drucker 1941, p. 143 seemingly agrees with the statement above.

[9] Driver 1941 summarizes and analyzes the data on girls' puberty rites in western North America. Spier 1930 and DuBois 1932 cite distributions over most of North America.

[10] Driver 1941, p. 37 states that the absence of public recognition affiliates the girls' rite of the Yuman peoples with the Great Basin area. The similarity may be due to non-elaboration in both areas of a basic western North American puberty rite.

[11] See Spier 1933, pp. 325-327 (Maricopa), Forde 1931, pp. 152-154 (Yuma), Gifford 1933, pp. 289-290 (Cocopa).

Kroeber, A. L. 1902. "Preliminary sketch of the Mohave Indians" American Anthropologist n.s. v. 4 (April-June) pp. 276-285.

———— 1925. Handbook of the Indians of California Bureau of American Ethnology Bulletin 78 (Washington).

Spier, Leslie. 1932. Klamath ethnography University of California Publications in American Archaeology and Ethnology v. 30 (Berkeley).

———— 1933. Yuman tribes of the Gila River University of Chicago Publications in Anthropology, Ethnological Series (Chicago).

BACTERIOLOGY

Chairman: S. E. HARTSELL, Purdue University

Mr. M. S. A. Campbell, Indiana State Board of Health, was elected chairman of the section for 1948.

ABSTRACTS

Corn steep liquor in microbiology. H. KOFFER and R. WINSTON LIGGETT, Purdue University and A. E. Staley Manufacturing Co., Decatur, Illinois.—A review was given on the manufacture of corn-steep liquor, its chemical composition, and its significance in microbiology especially in the production of penicillin.

Antibiotic behavior patterns of living cultures of Pseudomonas. R. L. KENT, Indiana Central College.—Curves of inhibition were plotted for three cultures of Pseudomonas over a period of ten weeks with *Staphlococcus aureas* as test organism. This technique differs from other antibiotic testing in that the Pseudomonas cultures are not destroyed, each culture being tested weekly for the ten week period. Incidence of parallel and non-parallel between pigment production and antibiotic activity was also noted.

The world influenza center in London. H. M. POWELL, Lilly Research Laboratories.—During the latter part of July this year (1947) the writer attended the Fourth International Congress for Microbiology in Copenhagen. At these meetings a group of some two dozen persons interested in the subject, met one afternoon to discuss what might be done on influenza virus study in anticipation of influenza which might become pandemic. It is apparent that the present specified types A and B influenza virus vaccine would be either (1) effective, or (2) scarcely at all effective, and this might depend largely on the relationship of any new pandemic strains of virus to strains of virus in the vaccine. In event the latter alternative should prove to be the case, it seemed wise to plan a definite sort of world wide action which could be done well in advance of epidemic influenza but which could not be done at the eleventh hour with influenza in full swing. It was decided to request through one of the members of this informal meeting, namely Dr. R. Gautier, of the Geneva Office of the United Nations World Health Organization, that United Nations sponsor a World Influenza Center. The two purposes would be (1) to gather and distribute without delay information about fresh outbreaks of influenza and (2) to act as a depository and exchange of influenza virus strains which might be studied antigenically, etc. if possible.

The writer has received on September 19, 1947, a communication from Dr. R. Gautier of date of September 15 from Geneva, Switzerland, to the effect that the interim commission of the World Health Organiza-

tion has decided to allocate $3,000 for financing a beginning World Influenza Center in London. An accompanying note by Dr. C. H. Andrewes of the National Institute of Medical Research, Hampstead, London, and who will organize the Center, sets forth the lines of activity which the Center will pursue. Some of the difficulties are cited, however Dr. Andrewes states the difficulties should not be insuperable.

Prospective work on the Influence Center was described, and possibilities and also limitations of influenza virus vaccine improvement were discussed.

The use of self attenuated influenza virus vaccine intranasally on Swiss mice. H. M. POWELL and W. A. JAMIESON, Lilly Research Laboratories, Indianapolis.—Commercial influenza virus vaccine (Proc. Ind. Acad. of Science. 1945, 54, 66 also Jour. Ind. State Med. Assn. 1946, 39, 68) is usually prepared by injecting seed virus in small doses, such as 10^{-3} to 10^{-5} cc into embryonated eggs, and incubating about 48 hours, then treating the virus so obtained with formalin. Recently we have prepared "self-attenuated" influenza vaccine by injecting eggs with large doses of seed virus, namely 10^{-1} cc, and incubating 96 hours. Resulting preparations described previously in part as "interfering factors", etc., (Jour Exp. Med. 1944, 79, 361 and 379 also Amer. Jour. Med. Sci. 1944, 207, 705 and 717), have lower hemagglutinating power than active virus, and virulence for mice is practically nil. Self attenuated vaccine given intranasally to Swiss mice in roses of 0.05 cc of 2×10^{-2} dilution produces strong type specific immunity up to eight weeks in duration, and equal to that produced by commercial vaccine when given intraperitoneally. Commercial vaccine, however, is entirely ineffective when used intranasally. Furthermore, the present attenuated vaccine is ineffective when used intraperitoneally, and also ineffective intranasally after being subjected to formalin treatment.

Type specificity and duration of immunity produced by self attenuated vaccine make this agent appear different from interfering or blocking factor. We have observed microscopic, but usually not gross lesions in a fair proportion of mice treated intranasally with self attenuated vaccine. Such mice seem quite normal physically in contrast to mice treated with weak dilutions of active virus.

Examination of food and drugs in the laboratories of the Indiana State Board of Health. GLEN C. WEBER, Indiana State Board of Health.—The Food and Drug Laboratory furnishes technical evidence necessary for the enforcement of the National and State Food, Drug and Cosmetic Acts in Indiana, and has a public health function as a part of the system for prevention of food borne epidemics and infections.

The chemical part of the program is devoted to analyzing pharmaceutical products qualitatively and quantitatively for presence and amount of dangerous drugs; analyzing foods for harmful or illegal adulterants; and to determining amounts of principle ingredients in foods and drugs when such are suspected of being sub-standard.

The biological part of the program includes the examination of foods and drugs for insect or rodent infestation; determination of mold

in tomato products; examination of processed foods, meats, fish, and poultry for spoilage; and the bacteriological and chemical analysis of foods implicated in food poisoning epidemics.

Observations on the chemical nature of the hemolytic and lethal factors of *Clostridium hemolyticum* toxin. R. C. BARD and L. S. MCCLUNG, Indiana University.—Chemical study of the toxin of *Clostridium hemolyticum* revealed that in addition to the existence of a lecithinase (named correctly as lecithinase D, the enzyme responsible for the LV reaction) another hemolytic factor was involved. Lecithinase D activity was measured satisfactorily by the manometric technic of Zamecnik, Brewster and Lipmann substituting a special egg yolk-saline suspension for purified lecithin; the manometric technic was found to be less sensitive than the familiar tube LV reaction. The additional hemolytic factor was shown to resemble lysolecithin. This conclusion was based on the specific hydrolytic action of lecithinase B, the enzyme catalyzing lysolecithin breakdown and destroying the hemolytic capacity of the additional toxic factor. Lecithinase B was isolated from old rice bran according to the method of Contardi and Ercoli. Since lysolecithin has been shown by Belfanti to induce severe pathology in experimental animals, the role of the lysolecithin-hemolysin described above was investigated further with regard to its lethal action. *C. hemolyticum* toxin treated with lecithinase B for 21-24 hours lacked not only the hemolytic potency due to lysolecithin but also any lethal factor for white mice. This latter finding suggests that lysolecithin functions in the lethal mechanism associated with *C. hemolyticum* toxin. The lysolecithin-hemolysin complex found in this toxin and in the toxin of *Clostridium novyi*, type B, as reported previously, is possibly the common antigen noted in serological studies of these toxins.

The Newer Knowledge of Lysozyme and Bacteria*

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In recent years considerable interest has been aroused in the general subject of microbic associations. The literature has been searched by many investigators to see if the organism of their particular interest has been involved in any special events such as synergism, commensalism, symbiosis, metabiosis, or antibiosis. As the search progressed, the investigator found that the latter phenomenon—antibiosis—was one of the first microbic associations to be studied. And in the literature on the subject, the antibiotic substance, lysozyme, has a distinctive position. Before Fleming recorded his observations about *Penicillium notatum* and staphylococci, he had studied the antibiotic activity of egg white extensively and described (1) the effects on bacteria of the substance he called "lysozyme". Thompson (2, 3) has reviewed the early literature on lysozyme so the present account concerns the more recent information on the subject.

What is Lysozyme?

Lysozyme is a basic polypeptid of low molecular weight that acts as an enzyme and hydrolyses certain mucopolysaccharides. When this hydrolysis occurs within or on bacteria in the presence of this substance, lysis results,—hence the name "lysozyme".

The Occurrence of Lysozyme

Lysozyme is apparently widely distributed in nature. In the tissues and secretions of man, it has been found in tears, nasal mucus, saliva, inflammatory exudate, cartilage, spleen, kidney, liver, lungs and lymph glands. Cartilage is particularly high in its lysozyme content. Lysozyme apparently does not occur in normal urine, cerebro-spinal fluid, sweat, aqueous humor and lens tissue. The tissues of rabbits and guinea pigs have less lysozyme than man; dog tissue is mid-way between these two animals in lysozyme content. The occurrence of lysozyme in the tissues of man is apparently influenced at a given time by the status of his health. Colds appear to reduce the amount of lysozyme in the nasal secretions. Stimulation of tear glands by pilocarpine and hypersecretion of the glands reduces the lysozyme titer. The influence of an avitaminosis on the lysozyme content of the tissue is debatable; at least very little reliable information is at hand to clarify this point.

Lysozyme has recently been isolated by Meyer, Hahnel and Steinberg (4) from Fiscus latex. Fiscus lysozyme is somewhat different chemically and immunologically from egg-white lysozyme and has a much lower potency as determined by lytic activity on bacteria. Cabbage,

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** The author is grateful for the assistance of J. F. Dodds and A. Smolelis in reviewing the literature.

turnip, cauliflower, *Euphorbia*, and even bacteria, themselves, are sources of lysozyme. Castaneda (5) observed lysozyme from donkey milk and noted its activity as being much less than that from egg-white. The wide occurrence of lysozyme, or lysozymes, in nature is apparent.

The principal source of lysozyme is egg-white from which it has been recently isolated in a very highly purified form by Alderton, Ward and Fevold (6). Alderton and Fevold (7) reported the preparation of the chloride, bromide, iodide, nitrate and carbonate of lysozyme in crystalline form. Good yields of the enzyme were obtained by direct crystallizations from homogenized, acidified egg-white to which 5% salt had been added. One of their co-workers, Jones (8) has reported the optical and crystallographic properties of lysozyme chloride in great detail. Crystals of this substance are colorless, tetragonal, tubular by-pyramids of the first order, usually showing a short pyramid of the second order. The shape of the crystal is a rhombic dodecahedron, giving uniaxial (+) inference figures and the face angle is 144°.

The chemical and physical properties of lysozyme

It is appropriate that we review the chemical and physical properties of this substance before considering the mechanism of lysis wherein bacteria are involved.

As stated previously, lysozyme is a basic protein or polypeptid of low molecular weight—reported as 13,000 by Pasynskii and Plaskew (9), 17,500 by Alderton and Fevold (6) and as about 25,000 by Meyer, Thompson, Palmer and Kharazo (10). The methods for determining the molecular weight appears to account for these differences. The molecular size of lysozyme is less than 30 millimicrons as determined by the osmotic pressure and ultracentrifuge methods. Lysozyme is soluble in acidified aqueous mediums and insoluble in alkaline mediums. Pure preparations are less stable but stability increases down to pH 4. The isoelectric point of lysozyme is given as pH 10.5 to 11.00 by Alderton, Ward and Fevold (6), however, Pasynskii and Kastarskaya (11) report the isoelectric point as pH 6. The wide difference is explained by the latter authors as due to the buffers used.

Lysozyme is filterable in acid solutions, is inactivated rapidly by heat in neutral or alkaline solutions, however, partially purified solutions retain their original activity after being kept at 100°C. for thirty minutes at pH 4, (Linz, 12). The lytic activity of lysozyme in rehydrated whole eggs is evident when diluted in phosphate buffer at a pH of 6.2 and heated for 90 minutes at 85°C. (Hartsell, 13). Lysozyme is very active at temperatures of 50°C., however, satisfactory measurements of the progress of lysis can be made at 37.5°C.

Lysozyme is insoluble in pure organic solvents but is soluble in dilute alcohol and water. According to Linz (12) it is precipitated but not inactivated by chloroform, ether, acetone, alcohol and toluene. It is inactivated by oxidizing agents and the salts of the heavy metals. Since the inactivation can be reversed by H_2S or HCN, Meyer, Thompson, Palmer and Kharazo (10) determined that one active group in the lysozyme molecule is the sulfhydryl radical. Ermoleva (14) determined

the chemical composition of lysozyme as 0.64% sulphur, 0.25% phosphorus, 6.4% hydrogen, 48.65% oxygen and 15.0% nitrogen. The amino acids— trytophan, tyrosine, cystine, and arginine have been detected in purified preparations of lysozyme. Fraenkel-Conrat and Olcott (15) have esterified lysozyme by alcohols of low molecular weight.

Several factors are known to influence lysozyme activity in the presence of susceptible bacterial cells. Bile and high concentrations of sodium chloride slow down its action on sarcina, whereas gastric juice and low concentrations of sulfonamides (1%) do not inactivate it, according to Cabezas and Rubina (16). Feiner, Meyer and Steinberg (17) observed that ferrous sulfate apparently inhibited the sensitivity to lysozyme, and sodium pyrophosphate counteracted this inhibition; sodium arsenate consistently increased the titer four-fold. Sulfathiazole-diazo-symetrical-carbamide-2R acid completely suppressed lytic action of lysozyme on *M. lysodeikticus*, (Lawrence and Klingel (18)). Either ferrous or ferric iron will overcome egg white inhibition of this organism (Schade and Caroline, (19)). Casein stimulates the action of lysozyme according to Paikina (20), who reasoned that some component other than glycine was responsible for the effect noted, since this amino acid is not present in casein.

The properties of lysozyme as an enzyme have been observed. Meyer, Palmer, Thompson and Kharazo (10) found that lysozyme did not have protease, kinase, amylase, lipase or phosphatase activity. Schultze (21) observed that lysozyme from fresh egg white was free of proteinase activity. However, Meyer and Hahnel (22) regard it as similar to another mucolytic enzyme, hyaluronidase, because, in both systems the chloride ion greatly increases the activity of the enzyme, both affect the substrate by depolymerase activity and both can be reversibly oxidized.

Lysozyme is antigenic and will give specific precipitin reactions. However, lysozyme from human saliva, from cat saliva and from *Fiscus globatra* do not give cross-reactions though they possess the common property of causing lysis in sensitive bacteria. Smolens and Charney (23) confirmed the antigenicity of crystalline lysozyme and observed that antilysozyme rabbit serum inhibits the activity of lysozyme on *M. lysodeikticus*.

The Action of Lysozyme

The lysis of bacterial cells would appear to be a process that could be followed in an orderly manner and that reproduceable results could be obtained. However, the difficulties of studying lytic phenomena with bacteria as the test organism are well known. In the early studies, qualitative expression of lysis as it progressed, or as it reached the end point (complete clearing of a given suspension), was sufficient for most experimental purposes. Recently, greater precision was desired in measuring the process. Meyer and Hahnel (22) determined lysozyme viscosometrically with greater accuracy than by the use of bacteriological methods. They found that bacteria vary greatly in their sensitivity to lysozyme according to the media upon which they are grown,

the strain and the method of killing the cells before testing for lysis. Quoting these authors—"The explanation for this variation apparently lies in changes in the autolytic enzymes contained within the bacterial cell, which contribute to a varying degree to the visible clearing of bacterial suspensions." Thus we see that bacteriolysis by lysozyme is a complex phenomenon.

The method of Boasson (24) has been used extensively. In this procedure the progress of lysis is followed with the aid of a Moll-extinctiometer. As a heavy suspension of the organism is lysed corresponding changes in the reading on the galvinometer are registered. Thompson (25) measured the lysis of sensitive cells photoelectrically. The instrument he used was not indicated in the reference. Fleming (1) measured its action by noting the clearing of suspensions and the destruction of organisms in plate cultures. Thompson (25) also used the latter procedure.

Klemparskaya (26) noted that bacteria may be grouped according to whether they are lysed or whether they are flocculated. He found that the flocculation phenomenon was conditioned by the pH and the concentration of the lysozyme. He believed that the difference in behavior of various organisms was due to their different colloidal structures. Lysozyme has been observed to inhibit the growth of bacterial cells without causing lysis, however no units for measuring this inhibition have been proposed.

Living bacterial cells of susceptible species are more sensitive to lysozyme than dead cells. However, Boasson (24) believes that dead cells are preferable in experiments with lysozyme. These cells killed by acetone, alcohol or heat are somewhat less sensitive than those killed by phenol or cold, neutral acetone. The essential features of the substrate,—that is, the bacterial cell—is that it must contain an acetylated aminopolysaccharide if lysozyme is to cause lysis.

From the work of many investigators it is possible to recognize three phases of the mechanism of lysis of bacteria: 1. adsorption of lysozyme onto the cell surface containing the specific substrate upon which the enzyme acts, 2. depolymerization of the substrate and 3. visible alteration of the cell—so-called "lysis".

The entire process has been extensively studied by Dorfman and his co-workers (27, 28, 29, 30). By using Abramson's modification of the micro-electrophoretic chamber of Northrop they observed that in the adsorption phase there occurred a rise in the electrokinetic potential at the cell surface in the case of sensitive cells (*M. lysodeikticus*). The effect occurs immediately and persists for a short time, after which the potential returns to normal. The reverse of the process is noted in strains, such as *B. subtilis*, that are insensitive to lysozyme. Substances obtained from lysed bacterial cells or impurities in the lysozyme did not influence the kinetics of the reaction. It is interesting to note that Dorfman and his co-workers suggested that electrokinetic potentials are an efficient way of measuring the effects of other antibiotics such as penicillin, bacteriophage and tyrothricin. These substances apparently affect the cell in such a way that electrically charged particles are

dissociated. From the work of other investigators adsorption of lysozyme is inhibited by increasing concentrations of salt. Shabordin (31) observed that bacteriolysis of dead and live cells by lysozyme behaves as an unimolecular reaction. The reaction can be reversed by extraction in acid alcohol.

In the second phase, lysozyme acts specifically on the acetylated aminopolysaccharide in sensitive cells changing it to N-acetylamino-hexose and ketose. The aminohexose is present in an insoluble form. Lysozyme is capable of attacking organisms or substrate when either is combined with antibody. Several environmental factors, such as temperature, pH, etc. are known to influence this phase of the reaction. As depolymerization proceeds, reducing sugars appear in solution, oxygen uptake ceases, non-protein nitrogen and inorganic phosphorus appear in solution and the gram reaction of *M. lysodeikticus* becomes gram negative.

The change in the gram reaction is an interesting observation. A brief summary of the bacteria which are sensitive to lysozyme reveals that the gram negatives are usually not affected, whereas the gram positives, especially saprophytic cocci, are lysed. In our studies on the microflora of rehydrated, spray-dried whole egg powder we found sensitive and insensitive strains of micrococci (gram positive) and flavobacteria (gram negative). Chemical studies on the identification of the substrate in these cells have not been made. These findings raise a question about the validity of lysis as an indicator of the presence of the substrate in the bacterial cell.

The third phase of bacteriolysis by lysozyme is closely related to the second phase, since the end point of the process—visible lysis—is accomplished after a succession of effects upon the cell has occurred. As depolymerization progresses there occurs a swelling of the cell as observed under the microscope and an increased permeability of the cell membrane (Babudiere and Bietti, 32). These effects result in the liberation of the contents of the cell. Boasson (24) and Babudiere and Bietti (32) found that the cell membrane was intact after lysis and that the swelling of the membrane is not due to a mechanical artifact. As has been previously indicated autolytic enzymes are believed to aid in the process of destruction. In the residue of what was once intact cells, particles of various sizes appear. Dorfmen (28) measured these particles and considered them proportional to the rate of lysis. Particles from lysed, heat-treated cells had greater size than those from living bacteria or phenolized cells. As lysozyme acts upon the cell it is not used up, however, inhibition of lysozyme by the products of lysis has been noted (Thompson, 2).

Fleming (1) observed that the rate of lysis is directly related to temperature; the rate increasing to a maximum at about 60°C. Anderson (33) and Thompson (2) found that maximum lysis occurred at 55°C. In recent work with lysozyme from rehydrated, spray-dried, whole eggs the author (13) conducted the experiments at 52°C, observing that lysis of sensitive cells was very rapid at that temperature. Other effects of temperature on lysozyme were noted by incubating the cell-lysozyme

suspensions at 85°C for varying periods of time. The rapidity of lytic activity was directly proportional to the time of exposure. As recorded previously, lysozyme from this source was still active on *M. lysodeikticus* after 90 minutes of exposure at 85°C.

The hydrogen ion concentration of the suspending medium in which lysozyme is active influences the process of cytolysis. Fleming (1) found that maximum lysis occurred at a pH of 7.0. However, Boasson (24) observed lysozyme to be most active at pH 6.2. Epstein and Chain (34) exposed lysozyme-cell mixtures at a pH of 4.5 in phosphate buffer and then added a small amount of normal NaOH to check the fact that the cells of *M. lysodeikticus* had been affected. There apears to be little agreement among investigators regarding the correct pH or the optimal suspending medium in which to determine the effect of lysozyme on a culture. It is probable that the cell protein of each strain of microorganism would have a pH at which its solubility was greatest, which may or may not be the pH at which lysozyme acts best. Meyer, Thompson, Palmer and Kharazo (10) and Epstein and Chains (34) have observed this correlation.

Another factor that influences the lysis of bacterial cells by lysozyme is the medium upon which the culture is grown. Kopeloff, Harris and McGinn (35) found the susceptibility of micrococci to increase if the culture was grown on beef extract agar instead of digest agar. Meyer and Hahnel (22) also found that the sensitivity of *M. lysodeikticus* varied with the medium in which the culture was grown. Since strains of the coccus varied in their sensitivity to lysis, they preferred the viscometric method to the bacteriological method for measuring lytic activity.

Still another factor influences lysozyme activity—that of concentration. Obviously, the rate of lysis would be dependent upon the amount of lysozyme acting upon sensitive cells, however, the sequence of events when an excess of the substance is used under optimal conditions has not been recorded. Thompson and Kharazo (36) found that pathogenic bacteria will be attacked if the concentration is great enough.

Lysozyme and Viruses

Having reviewed what lysozyme is, and how it acts, I would like to direct your attention to the viruses and bacteria, other than *M. lysodeikticus*, upon which lysozyme has been tested.

The only report of the action of lysozyme (undiluted egg white) on viruses to come to the attention of the author is that of Scheidegger (37). No inactivation of vaccine virus, fixed rabies virus, herpes virus, the eastern strain of equine encephalomyelitis virus, influenza virus (human strain W. S. and swine strain Shope) or the virus of fowl plague could be detected.

Lysozyme and Bacteria

Lysozyme is most active on certain saprophytic cocci. *M. lysodeikticus* is the most sensitive of the bacteria. Thompson (3) recorded a summary of the *pathogenic* bacteria previously used in studies on lysozyme and then stated as had Fleming (1), that many strains of *saprophytic* bac-

teria, yeasts and two molds had been found to be sensitive to lysozyme. No complete record of the saprophytic genera used was given. In the author's report (13), referred to previously, the insensitivity of bacilli, *Achromobacter*, *Aerobacter*, *Bacterium* and certain sarcina to lysis of lysozyme is noted. The variable sensitivity of strains of micrococci and *Flavobacterium* are also recorded. *Escherichia coli* like other gram negative bacteria, is not sensitive to lysozyme under the usual conditions for testing bacteriolysis.

However, gram negative bacteria that are frequently pathogenic may be killed by lysozyme. *Vibrio cholerae* has been killed by 25% egg-white; *Eberthella typhosa* by 50% egg-white. *Klebsiella*, brucella, streptococci and most strains of staphylococci are sensitive to lysozyme. Neisseria and mycobacteria are reported as sensitive to partially purified lysozyme. No anaerobes have yet been subjected to lysozyme under experimental conditions; so wrote Thompson in 1940. This statement still holds true. The several factors that condition the process of lysis must be recalled when interpreting the sensitivity of strains, as recorded in the literature and when projecting work for the future. Thompson (2) wrote—"Provisionally it seems justifiable to include lytic actions of lysozyme-containing materials on various saphrophytes as evidence of lysozyme action". But bacteria are subject to variation in their reaction to lysozyme so a negaitive test for lysis requires further explanation. Either of three possibilities are apparent: (1) the substrate is not within the cell therefore lysozyme could not act upon it, or (2) the substrate was there but no lysis was possible because conditions for the solubility of the cell substances were not optimal, or (3) the substrate was there, the conditions for the solubility of cells substance were optimal but the permeability of the cell wall could not be altered to allow the cell substance to pass from it. In the latter situation inhibition of growth would result, but no lysis would be observed. Only further experimentation will prove the validity of this reasoning. Furthermore, the natural tendency of microorganisms to vary confuses the explanations of bacteriolysis by lysozyme.

Resistance to lysozyme can be cultivated in bacteria. Fleming (1) and many other investigators have observed this phenomenon. Lysozyme resistant cells are not easily phagocyted, which suggests that the lysozyme, —or should we say lysozymes—in the host may serve to cause a pathogenic strain to change if it would continue to invade the host. A positive correlation exists between lysozyme resistance and certain common indicators of virulence in staphylococci, i.e. pigmentation and coagulase production. However, too little information is available to appraise the significance of microbic variation in the process of pathogenesis wherein lysozyme is active.

Reference should now be made to substances closely related to lysozyme—the so-called "avidin-biotin" complex. Lawrence (38) believed that lysozyme was biotin-saturated avidin. The work of Gyorgy and Rose (39); Eakin, Snell and Williams (40); Wooley and Longworth (41) and Alderton, Lewis and Fevold (42) clearly separates avidin, biotin and lysozyme.

The Biological Significance of Lysozyme

Considering the investigations on the occurrence of lysozyme, the mechanism of its action and the effect it has upon the bacterial cell, we should expect certain broad generalizations regarding its biological significance..

The effect of lysozyme on the bacterial cell, as has been indicated by Dubos (43), offers another method whereby the chemical composition of the cell can be discerned. Since lysozyme acts on a specific substrate, lysis of the cell by lysozyme can be construed as evidence of the acetlyated aminopolysaccharide in that cell. Insensitive cells would not possess this substrate if the reasoning, and subsequent experimentation, are correct. The prospect of grouping bacteria into two categories—the *lysozyme-sensitive* (show visible lysis) and the *lysozyme-insensitive* (show no visible lysis)—would appear to have taxonomic significance. However, there is need for caution in using such a grouping until more detailed information about purified lysozyme acting on a wide variety of genera are available. Bacilli, and many gram negative bacteria, are insensitive to lysozyme whereas many cocci, including the pathogenic types, are sensitive.

It remains to be seen whether lysozyme could have more than a limiting effect upon bacteria *in vivo*—perhaps causing a slight variation of the pathogen, making it less susceptible to lysis. Thompson (2), first, considered this possibility when he wrote—"A first step in the evolution from susceptible saprophyte to parasite would certainly require the development of a mechanism of resistance to this enzyme, whether or not this were the only requirement for such a step". Recent investigations do not detract from, or add to, this view.

The significance of lysozyme in the tissues of man cannot be properly appraised. Meyer and Hahnel (22) do not consider lysozyme to have a metabolic function in the host since the wide occurrence of the substrate of lysozyme in extracts of organs has not been shown. Since lysozyme occurs in some tissues in great abundance, and to a lesser extent in other tissues, the prospect of increasing the lysozyme content of all tissues artificially offers an interesting field of investigation. The possible additive effects of lysozyme and other tissue components to prevent the invasion of pathogenic microorganisms offers a fertile field of investigation. In disease, an increase in the lysozyme in the area of the affected tissue appears to have some beneficial effect. Ponomareva (44) found that lysozyme in contact with suppurative surfaces hastened the healing process and promoted granulation without modifying the tissue. A second effect noted in the application of lysozyme was the destruction of many pyogenic bacteria, however, he observed (45) that, if lysozyme was used over a long period of time, lysozyme-fast or resistant strains developed.

Finally, the function of lysozyme in the resistance mechanism of the shell egg has received little attention from investigators. This is an unusual observation since egg-white has served as a ready source of lysozyme for so many years.

References

1. Fleming, A. On a Remarkable Bacteriolytic Element Found in Tissue and Secretions. Proc. Roy. Soc. (London), B., **93**:306-317, 1922.

2. Thompson, R. Lysozyme and Its Relation to the Antibacterial Properties of Various Tissues and Secretions. Arch. Path., **30**:1096-1134, 1940.

3. Thompson, R. Lysozyme and the Antibacterial Properties of Tears. Arch. Ophhtal., **25**:491-509, 1941.

4. Meyer, K., E. Hahnel and A. Steinberg. Lysozyme of Plant Origin. Jr. Biol. Chem., **163**:733-740, 1946.

5. Castaneda, A. M. Preliminary Note on the Isolation and Partial Purification of a Lysozyme of Donkey Milk. Gaceta Med. Mex., **76**:165-169, 1946.

6. Alderton, G., W. H. Ward, and H. L. Fevold. Isolation of Lysozyme from Egg White. Jr. Biol. Chem., **157**:43-58, 1945.

7. Alderton, G. and H. L. Fevold. Direct Crystallization of Lysozyme from Egg White and Some Crystalline Salts of Lysozyme. Jr. Biol. Chem., **164**:1-5, 1946.

8. Jones, F. T. Optical and Crystallographic Properties of Lysozyme Chloride. Jr. A. Chem. Soc., **68**:854-857, 1946.

9. Pasynskii, A. G. and V. Plaskew. Diffusion and Molecular Weight of Lysozyme Comp. Rend. Acad. Sci., U.R.S.S., **48**:579-581, 1945.

10. Meyer, K., R. Thompson, J. W. Palmer and D. Kharazo. The Purification and Properties of Lysozyme. Jr. Biol. Chem. **113-114**:303-309, 1936.

11. Pasynskii, A. G. and T. Kastarskaya. Electrophoresis of Lysozyme by the Tiselius Method. Comp. Rend. Acad. Sci., U.R.S.S., **49**:504-7, 1945.

12. Linz, Roger. Purification of the Lysozyme of Egg White. Comp. Rend. Soc. de Biol., **126**:1279-80; 1281-1282, 1937.

13. Hartsell, S. E. The Lysozyme Activity of Rehydrated Spray-dried Whole-egg Powder. Food Res. **13**:136-142, 1948.

14. Ermoleva, Z. V. Lysozyme Uspekhi. Souremennoi Biol. **9**:68-80, 1938. Khim. Referat. Zhur., **2**:61, 1938.

15. Fraenkel-Conrat, H. L. and H. S. Olcott. Esterification of Proteins by Alcohols of Low Molecular Weight. Jr. Biol. Chem. **161**:259-68, 1945.

16. Cabezas, J. and M. Rubina. Lysozyme. Anales quim. farm. (Chile), 9-17, 1942.

17. Feiner, R. R., K. Meyer and A. Steinberg. Bacterial Lysis of Lysozyme. Jr. Bact., **52**:375-384, 1946.

18. Lawerance, C. A. and H. Klingel. Effects of Azosulfonamides on Lysozyme. Proc. Soc. Expl. Biol. Med., **52**:129-130, 1943.

19. Schade, A. L. and L. Caroline. Raw Hen Egg White and the Role of Iron in Growth Inhibition of *Shigella dysenteriae, Staphylococcus aureus, Escherichia coli* and *Saccharomyces cerevisiae.* Science, **100**:14-15, 1944.

20. Paikina, S. Sh. The Stimulating Effect of Casein on Lysozyme. Chem. Zentralbl., **1**:499, 1942.

21. Schultze, H. E. Peptidases in Egg White and Their Preparation. Z. Physiol. Chem., **279**:89-93, 1943.

22. Meyer, K. and E. Hahnel. The Estimation of Lysozyme by a Viscosometric Method. Jr. Biol. Chem., **163**:723-732, 1946.

23. Smolens, J. and J. Charney. The Antigenicity of Crystalline Lysozyme. Jr. Bact., **54**:101-107, 1947.

24. Boasson, E. H. On the Bacteriolysis by Lysozyme. Jr. Immunol., **34**:281-293, 1938.

25. Thompson R. Certain Antibacterial Properties of Saliva and Tears not due to Lysozyme. Jr. Bact., **41**:77, 1941.

26. Klemparskaya, N. N. Flocculation of Bacteria by Lysozyme. Z. Microbiol. Epid. Immunitätsforschung, No. 2-3, 124-128, 1939.

27. Dorfman, V. A. and E. I. Karakash. Bacteriolysis. Study of the Oxidation-reduction and Electrokinetic Potentials in the Process of Bacteriolysis. Byull. Ekspth. Biol. Med., **13**:48-52, 1942. C. A., **38**:4642, 1944.

28. Dorfman, V. A. Bacteriolysis. II. Kinetics of the Lysozyme Lysis. Id., **14**:112-114, 1942.

29. Dorfman, V. A. Physiochemical Nature of Bacteriolysis. Nature, **153**:169-170, 1944.

30. Dorfman, V. A. On the Physiochemical Nature of Bacteriolysis. Amer. Rev. Sov. Med., **2**:271, 1945.

31. Shabordin, D. A. Photometric Determinations of Lysozyme Activity. Arch. Sci. Biol., U.S.S.R., **60**:83-86, 1940. C. A., **35**:598, 1941.

32. Babudieri, B. and G. B. Bietti. Electron Microscopic Observations on Bacterioysis Produced by Lysozyme of Tears. Arch. Ophth., **33**:449-454, 1945.

33. Anderson, O. Untersuchungen uber das Lysozym aus dem Micrococcus Lyodeicticus. Ztschr. F. Immunitätsforch. u. Exper. Therap., **70**:90-103, 1931.

34. Epstein, L. A. and Chain, E. Some Observations on the Preparation and Properties of the Substrate of Lysozyme. Brit. Jr. Exp. Path., **21**:339-355, 1940.

35. Kopeloff, N., M. M. Harris and B. McGinn. Lysozyme in Saliva. Amer. J. Med. Sci., **184**:632, 1932.

36. Thompson, R. and D. Kharazo. Susceptibiity of Lysozyme to Staphylococci. Proc. Soc. Exp. Biol. and Med., **33**:299-302, 1935.

37. Scheidegger, E. Experimentalle Untersuchungen über die Wirkung von Lysozym auf menschen-und tierpathogene viruserten. Arch. f. d. ges. Virusforsch., **1**:394, 1940.

38. Lawrence, W. L. On the Possible Identity of "Avidin" and Egg white Lysozyme. Science, **99**:392-393, 1944.

39. Gyorgy, P. and C. B. Rose. The Liberation of Biotin from the Avidin Biotin Complex (AB.) Bull. Hyg., **18**:1030, 1943.

40. Eakin, R. E., E. E. Snell and R. J. Williams. The Concentration and Assay of Avidin. Jr. Biol. Chem., **140**:535-543, 1941.

41. Wooley, D. W. and L. G. Longsworth. Isolation of an Antibiotin Factor from Egg White. Jr. Biol. Chem., **142**:285-290, 1942

42. Alderton, G., J. L. Lewis and H. L. Fevold. The Relation of Lysozyme, Biotin and Avidin Sci., **101**:151-152, 1945.

43. Dubos, R. The Bacterial Cell. Harvard University Press, 1946.

44. Ponomareva, O. I. Experimental Studies in Lysozyme. Amer. Rev. Sov., Med., **3**:426-431, 1946.

45. Ponomareva, O. I. Lysozyme in Surgery. Id., **3**:432-442, 1946.

BOTANY

Chairman: NOE HIGINBOTHAM, Argonne National Laboratory, Chicago

Dr. H. J. Brodie, Indiana University, was elected chairman of the section for 1948.

ABSTRACTS

Sexuality Studies of the Birds' Nest Fungus *Cyathus stercoreus*. HAROLD J. BRODIE, Indiana University.—*Cyathus stercoreus* has been grown in single basidospore culture. The single-spore mycelia are haploid and differ markedly from one another in color, texture and growth rate. Analysis of pairings of single sport cultures establishes the heterothallism and tetrapolarity of this fungus. Whereas in most of the higher basidiomycetes, haploid mycelia are approximately equally distributed among the sex groups, in *C. stercoreus* nearly six times as many haploids belonged to the *AB* and *Ab* groups as belonged to the *ab* or *aB* groups. Vigorous diploid mycelia result from the pairing of compatible haploid mycelia. The diploids differ from one another in color, texture and growth rate. Diploid mycelia fruit readily in culture on suitable medium. In this fungus, diploidization is usually of the regular type, both haploid mycelia of a compatible pair becoming fully diploidized. An unusual kind of behavior has also been noted in which only one haploid of the pair becomes diploidized.

A haploid Oenothera. RALPH E. CLELAND, Indiana University.—Haploid Oenotheras have been found very rarely. The presence of lethals in most Oenothera genomes precludes the possibility of the existence of plants containing such genomes in single dose. *Johansen* is an alethal race, hence there is the possibility of the appearance of the Johansen genome in a haploid plant. In the F_1 of *Johansen X Haskett*, a haploid individual appeared during the summer of 1947. The plant was clearly a haploid *Johansen* plant, differing from the normal 2n *Johansen* in having thinner and narrower leaves, more slender stems and buds, and smaller stature. It was, however, a strikingly robust plant, with good color. Chromosomes at diakinesis were found for the most part as separate univalents, but a few cases were observed where two chromosomes appeared to be united end to end. Practically no pollen was found in the anthers. Many small fruits were set, with a few seed in each. Attempts will be made to grow this seed.

The progress of succession in the Pennington grove of *pinus virginiana*, J. E. POTZGER, Butler University, and ESTHER WHITNEY-POTZGER, Canterbury College.—In 1932 the senior author published a report on stands of *Pinus virginiana* in Monroe County, Indiana. These stands had developed on badly eroded and wornout fallow fields within a span of about 45 years. The seeds came from several trees which early settlers

had planted near their houses. In 1932 the ground cover was wanting and very few seedlings of broadleaved trees had come in under the crown cover of the pine. In the study of 1947 the survey showed a rather conspicuous ground cover by herbaceous plants and 26 woody species were participating in the forest complex, more than twice the number listed in 1932. The young stems are primarily those of *Quercus velutina, Q. alba, Fraxinus lanceolata, Carya cordiformis, C. ovata,* but also some young saplings of *Acer saccharum* and *Fagus grandifolia* had made their appearance. *Cornus florida* has the greatest abundance in the small tree layer, *Pinus virginiana* was not represented by a single small tree below one inch in diameter. There is every indication that in another 15 to 20 years broadleaved genera will assume control even of the crown cover. Apparently *Pinus virginiana* has within the past 60 years made sufficient favorable changes in the soil factors to make it possible for broadleaved genera to invade the stand. It seems that this pine is an excellent tree to cover and reclaim wornout and eroded areas in southern Indiana and by a process of natural succession yield to a forest of broadleaved trees.

Ecological notes on the production of Terrones in the Rio Grande Valley. ALTON A. LINDSEY, Purdue University.—A terron is a building-brick cut from natural sod held together by the interlacing rhizomes and roots of sedge-meadow species, and sun-dried. Terrones have been used for hundreds of years in the Rio Grande valley in New Mexico; they still are used extensively, chiefly by the Indians and Spanish-Americans, many of whom consider terron construction superior to adobe. The plants which determine the useful properties of terrones are, in order of decreasing abundance, *Distichlis spicata* (Saltgrass), *Juncus balticus, Scirpus* sp., *Anemopsis californica.* Sod, from land uncut for at least six years previously, is removed to a depth of four to six inches by spade, or special machine drawn by tractor; the bricks are stacked, and dried for at least one month. From ground not stripped within living memory, the dried sub-surface plant parts in a terron weigh 3.35% of the dry weight of the soil alone. Following terron removal, and after four growing seasons of recovery, the rhizomes and roots weigh 0.45% of the soil weight; after fourteen growth seasons they weigh 0.82% of the soil weight. The first pioneer in this halosubsere is *Flaveria campestris,* which comes in the first spring after cutting terrones. A square meter of the four-year-old stand contains 543 tufts of Saltgrass (the dominant); a square meter of the 14 year growth has 902 tufts. An equal area of uncut sod produces 891 tufts of Saltgrass, but many more plants of the several other species than occur on the younger quadrat-areas. The average compressive strength of four dry terrones tested was 194.2 lb. per square inch; the strongest of them tested 252, or slightly better than the average for adobe bricks in this region.

The identification of dried mushrooms. C. L. PORTER, Purdue University.—The paper is a result of a year of study of a collection of dried mushrooms sent to the writer for purposes of identification. Identification was made difficult and the results were uncertain because of a lack of

pertinent data accompanying the specimens. The importance of the right kind of data at the time the collection of mushrooms is made is essential. The writer gives the results of his experiences and offers suggestions for those interested in the collection and drying of fleshy mushrooms.

Variation in the Common Sunflower, *Helianthus annuus*, CHARLES B. HEISER, Jr., Indiana University.—Viewed conservatively, the annual sunflowers comprise five species. Of these, *Helianthus annuus* L. is the most complex and variable. For purposes of convenience, three main races are recognized, which are as follows: first, the sunflowers of the Great Plains and western United States which are branched, small in stature, with small disks and few rays; second, the sunflowers of the Middle West and East which are similar to the first but much taller and with larger disks and more numerous rays; third, the giant monocephalic cultivated sunflowers. The second form has somewhat the general aspect of the hybrid between the western and cultivated sunflowers. The first two are weeds and have been widely distributed by man's agency, and appear to have hybridized extensively. Hence it is hard to assign distinct geographical distributions to them. The domestic form is widely cultivated in the United States and elsewhere and crosses between it and the branched forms are not uncommon. Another factor responsible for a large amount of the diversity encountered is hybridization between *H. annuus* and other species of annual sunflowers. *Helianthus annuus* is known to hybridize with *H. Bolanderi* and *H. petiolaris*, and hybridization is suspected to occur with *H. debilis (H. cucumerifolius)*. This hybridization has resulted in the phenomenon known as introgression and appears to have modified *H. annuus* rather extensively in the areas where the hybridization occurs. Although the writer has been engaged in a study of *H. annuus* for five years, a great deal more field and cytogenetical work still awaits to be done. These studies, it is hoped, should go a long way in throwing light upon the origin of the cultivated sunflower, one of the few new world crops to have been domesticated north of Mexico.

A study of the abscission of marcessent leaves of *Quercus palustris* **and** *Q. coccinea*. R. W. HOSHAW, Purdue University.—Stem sections of *Q. palustris* and *Q. coccinea* were collected each week and studied microscopically to determine the presence and nature of the abscission region and abscission layer. Microscopic sections were prepared by means of a freezing microtome and stained for study. Observation of these sections began on 15 February, 1947. By 5 April, 1947 most of the leaves had fallen from *Q. palustris*, and by 15 April, 1947 no leaves remained on *Q. coccinea*. *Quercus coccinea* displayed the more rapid rate of leaf fall. Before abscission was complete, many petioles of both *Q. palustris* and *Q. coccinea* broke allowing the leaves to drop. The remaining petiole stubs abscissed during the following three or four days. A large number of crystals were observed in the stems and petioles of both species. However, the abscission regions contained a greatly reduced number of crystals, at the present time a study is in progress to determine the exact time of the formation of the abscission layer.

Pigment Production in Non-Chlorophyllous Plants

Noe Higinbotham, Argonne National Laboratory

Introduction

It is well known that many bacteria and fungi are vividly colored but at present the significance of the pigments involved remains unexplained. The present paper is devoted to a review of some features of the general problem of pigmentation in these two groups including the chemical nature of the pigments, possible metabolic functions, and the factors influencing pigmentation.

Pigments of Bacteria, Fungi, and Lichens

In recent years a number of pigments responsible for coloration in the bacteria, fungi, and lichens have been rather well characterized chemically; many of these have been isolated and studied in a highly purified state so that it has been possible to ascertain structural formulas. From the three plant groups mentioned a total of 83 seem distinct, 59 pigments from the fungi, 15 from the bacteria, and 9 from the lichens (1, 3, 4, 9, 14, 23, 29, 30, 31, 37, 39, 40, 42, and 49).

A few colored substances seem to occur in (and be essential for) all organisms: the cytochromes, riboflavin compounds, carotenes, and, perhaps, thiochrome (the oxidized form of thiamin). These substances are metabolic agents or components of substances probably necessary for carbohydrate utilization in all living cells.

Chemically the pigments are quite varied in structure and only the more important classes need be considered. Some believe that acids, antibiotics, and pigments may be compounds related to one another in the organism (42, 50).

Significance of Pigmentation

The role in metabolism of the majority of pigments of bacteria and fungi is not known. The activity of the respiratory pigments, cytochromes and flavins, in the breakdown of carbohydrates now seems well established. There can be no doubt of the essential nature of the bacteriochlorophylls for the normal existence of the photo-synthetic bacteria. However, in comparison, little of a specific nature has been discovered of the activity of the carotenoids, the quinones, anthraquinones, the oxonium compounds, and other classes of biochromes. It seems certain that substances with the potential chemical activity of the above pigments play important roles and that studies in this field should be extremely promising. The dismissal, by some, of pigments as unimportant end-products seems unwarranted; in any case, it would be of great importance to know the reactions leading to the formation of pigments since in most cases they represent syntheses of compounds not easily made in the laboratory at the present time.

Despite the paucity of experimental work on the function of pigments in the organism some roles have been reported for them and others have been suggested on a hypothetical basis.

The photosynthesis by bacteriochlorophyll in the synthesis of carbon compounds (sugars?) from CO_2 is very similar to that of the higher green plants (39). It seems probable that the photochemical roles of both chlorophyll and bacteriochlorophyll are the same although the details of some of the steps in photosynthesis may differ.

With regard to the cytochromes there is an increasing amount of evidence that they are of very general occurrence and are of fundamental importance in biological oxidation as respiratory pigments. They form an oxidation-reduction system which is responsible for the transport of hydrogen and oxygen in the process of respiration leading to the release of energy and the final products, H_2O and CO_2 (49).

A point of great interest is the similar features of the cytochromes of organisms in general, the chlorophylls of plants, and hemoglobin of animals. One cannot help wondering whether the cytochromes may be the parent materials phylogenetically, of both hemoglobin and chlorophyll. From this standpoint the pyrrole pigment prodigiosin is of great interest since it may represent a precursor of the porphyrins or a degradation substance. In any case a search for other pyrrole pigments seems well worth while.

Friedhem (18), reported that phoenicin stimulated the respiration of unpigmented, washed cells of *Bacillus pyocyaneus* by 200-300 percent. A similar function was found for aspergillin which was therefore considered to be a respiratory pigment (42). Pyocyanine, also, in lower concentration stimulates respiration but in higher concentration it inhibits the growth of many bacteria and fungi (27). Pyocyanine is subject to either oxidation or reduction and it appears to act as a respiratory enzyme or coenzyme (49).

Raistrick (42) has expressed the view that several pigments probably function in oxidation-reduction systems. One line of evidence for this view is the occurrence in organisms of both reduced and oxidized forms in the cases of physcion, phoenicin and luteoleersin. The existence of equilibrium mixtures of the reduced and oxidized forms undoubtedly make them a part of the oxidation system but their relative importance in this respect remains to be studied quantitatively. The activity of such pigments can be compared with that of cytochrome and other hydrogen carriers in oxidative metabolism since they readily accept H ions to become reduced and lose them in oxidation.

A study of the effect of xanthones on metabolism revealed that rubrofusarin gave a 3% inhibition of the rate of dehydrogenation in nonpigmented *Fusarium lini* (36). However, there was a 40% increase in dry weight. Other xanthones (synthetic) increased the rate of dehydrogenation from 5 to 12%. Mull and Nord conclude that the xanthone derivatives may have a dual but interdependent effect and that synthesis may be enhanced or inhibited while dehydrogenation is depressed or increased according to the structure of the xanthone employed. They

consider that substances which have hitherto been regarded as insignificant "waste products" must be taken into account in enzyme studies.

It is readily seen that there are many pigments whose biological activity remains uninvestigated. From the structures represented these substances seem potentially as active in metabolism as many of the intermediates whose functions are now known. A number of pigments—fumigatin, spinulosin (42), citrinin (34) pyocyanine, iodinin, and litmocidin (19)—have been reported to be antibiotics. This again is an indication of reactivity but does not explain their role in normal schemes. The antibiotic activity of the quinones fumigatin and spinulosin is due to their oxidation of essential sulfhydryl compounds (42)—a process which may be of value under certain conditions. The mechanics of inhibition in other cases has apparently not been reported.

Another function ascribed to pigments is that of some unknown role in reproduction. In many non-green forms the spores and reproductive structures have a distinctly localized pigmentation. Metz (33) expressed the view that in *Aspergillus niger* the pigment was important in sporulation. Thom and Raper (51) discuss the change of color during development of the Aspergilli and suggest that pigment studies should be related to this change. They cite evidence relating certain changes in metabolism of the *Aspergillus flavus* group with color variations due to pH. Gray (22) found evidence for a photochemical reaction in the induction of myxomycete plasmodia to form sporangia. Only the pigmented forms were stimulated to fruit, the non-pigmented forms being insensitive to light in this regard. Gould and Railstrick (21) working with auroglaucin and flavoglaucin produced in *Aspergillus novus* noted that auroglaucin almost entirely disappeared during conidia formation. They further believed there was a correlation between perithecia formation and the accumulation of the two pigments. It is reported that γ carotene is the only carotene present in most species and it is restricted to the male reproductive cells in Allomyces (16). In *Mucor hiemalis* the plus strains produce greater amounts of β carotene than the minus strains (7).

Thus far no discoveries of pigment activity in the fungi and bacteria compare with the remarkable effect on sexuality in *Chlamydomonas* reported by Moewus and Kuhn (see reviews: 46, 47) of carotenoid pigments and other related compounds which act in a most striking system to control the motility of cells, the sex of gemates, their agglutination preliminary to conjugation, and the actual fusion of male and female gametes. Unfortunately this work has not received the confirmation or condemnation which it deserves. Nevertheless it suggests many possibilities and, for the first time, ascribes definite functions in reproduction to the carotenoids.

There are indications that the absorption of light prevents injury in several forms: *Microcera coccophila* (14), *Polyporaceae* (8), and *Puccinia graminis* spores (15). In the latter case red or gray-walled spores have a higher resistance to injurious effects or ultraviolet radiation than orange or clear-walled spores.

In some forms the accumulation of pigments appears to represent an unhealthy condition. Roberts (44) concludes that the pigmented cells

of *Torulopsis pulcherrima* are no longer able to grow and divide. In the Polyporaceae, Bose (8) found the coloring substances accumulated in the walls or in dead cells but not in living cells. These occurrences, however, do not necessarily signify that the pigments were the cause of the death of the cells since a deficiency or excess of many other substances may have been responsible. In the case of *Aspergillus novus*, which produces flavoglaucin and auroglaucin. Gould and Raistrick (21) obtained a yield of crude pigment equivalent to 43% of the mycelium dry weight. Yields in other cases are as high as 10-30%. Such high accumulations could surely not occur with excessively toxic compounds.

The Effects of Various Factors on Pigment Production

In the fungi the pigments may be variously localized, in some forms occurring in the mycelium and substrate, in others the color may be restricted to the aerial parts, and, in still other forms, only the spores may be colored. The coloration of aerial parts seems to be a relatively constant genetic feature and is universally used in the taxonomy of species. Most—but not all—of the quantitative measurements have been concerned with the biochromes found in both the mycelium and substrate. The latter pigments appear to result from an intimate interaction of the organism and its substrate and thus is an inherited characteristic sensitive to nutritive and environmental factors.

Physiological factors:—There have been many references to the influence of various environmental and nutrient factors on coloration, many conflicting statements have appeared, and very few general conclusions may be made. However, only recently has there been any effort to make quantitative measurements of pigments produced by organisms growing on a synthetic medium. Such quantitative observations seem necessary—in addition to the knowledge of qualitative effects—if an orderly understanding is to be gained. In addition, since the pigments represent a variety of compounds chemically, each fungus and each pigment constitute a different problem.

Among the factors found to influence pigmentation are light, temperature, organic nutrition, and inorganic nutrition.

Light:—The effect of light has been investigated in a number of species with variable results. Pigment formation is apparently induced or stimulated by light in *Microcera coccophila* (41), *Neurospora crassa* (23), and Coccosporium sp. (25). Light has no apparent effect on color formation of *Torulopsis pulcherrima* (44), several species of the Polyporaceae (8), and several myxomycetes (22).

Haxo (23, and private communication) found that the formation of carotinoids in Neurospora is stimulated by exposure to light. Relatively short exposures followed by incubation in complete darkness were sufficient to stimulate pigment formation.

Unpublished studies of *Coccosporium* show that in this form some pigment is formed in complete darkness but more is produced in the presence of light (25). Light is necessary for production of color in some bacteria also: *Serratia marcescens* (2); two unidentified species (6).

Temperature:—In general it appears that the temperature range optimal for growth also favors greatest pigment formation (12, 21). In *Torulopsis pulcherrima* temperature appeared to have no effect on the amount of pigment produced as estimated visually, but at temperatures above 19° C the pigment diffused out of the cells into the substate (44). In *Coccosporium* sp. best pigment formation occurs at 12-18° C while greatest mycelium growth requires about 25° C (24). On the other hand with *Fusarium coeruleum* on a sucrose medium no pigment is formed below 30° C, whereas 15-25° C is the optimal growth temperature (35).

In some chromogenic strains or coliform bacteria strong coloration occurs at 19° C but not at 37° C although growth is favored at the latter temperature (20). Bunting (11), in a study of *Serratia marcescens*, concluded that in this form lower temperatures favor a higher proportion of dark red to light-colored variants.

Oxygen:—Aeration plays an important role in pigment formation in many cases (24, 39, 44) and it seems probable that oxygen is usually essential for the process. However, in view of the recent discovery that non-green organisms may assimilate carbon dioxide, the problems of aeration in pigmentation should be more critically investigated. Brown (10) noted that *Sphaeropsis malorum* was stimulated in growth by carbon dioxide but he failed to record an effect on coloration. In the bacteria aeration is usually needed, but McClung (32) has already pointed out that despite a statement to the contrary there do exist a number of pigmented anaerobic bacteria.

According to Roberts (44) when *Torulopsis pulcherrima* cultures were grown in the absence of air no pigment developed but, then, if air was admitted, color appeared in 5½ hours. Roberts concluded that there must develop under anaerobic conditions a precursor substance, a chromogen, which requires only the presence of oxygen to be oxidized to the colored compound.

Osmotic concentration:—Species of the *Aspergillus glaucus* series do well in media of high osmotic concentrations, some tolerating a 50% glucose solution; greater pigmentation occurs under these conditions (21). Most species of bacteria and fungi do best on much weaker solutions and it seems improbable that osmotic concentration has any direct effect.

Hydrogen-ion concentration:—As in the case of most other environmental factors the optimal pH range for both growth and pigmentation are about the same (12, 14a, 21, 26, 44). However, hydrogen-ion concentration is a function of the organism and its substrate so that a marked shift of pH may occur during development, the direction being largely dependent upon the organic carbon and nitrogen sources. Frequently such changes may go beyond the range for best growth in which case less pigment is to be expected.

In *Penicillium carmino-violaceum* (26) and *Torulopsis pulcherrima* (44) changes toward an alkaline range increases the outward diffusion

of pigment. In *Coccosporium* photometric measurement of pigment in the substrate and the mycelium extract showed no significant difference in outward diffusion due to pH acocrding to Higinbotham and Powers (24). However, the later authors found that the initial pH value of the medium had a much greater effect on pigment production than on mycelium dry weight so that at certain values good growth was obtained with little pigment formation.

Mineral nutrition:—There are numerous reports of the effects of minerals on coloration of the bacteria and fungi. It seems obvious that the minerals essential for growth are also necessary if pigmentation is to occur. The need for Mg, P, and S has been affirmed repeatedly but the reports regarding the effect of Fe and other trace elemnts are in conflict. It seems probable, however, that Fe, Zn, Mn, B, Mo, Ga, and Cu, are essential for the growth of fungi and some of these particularly Fe and Zn, affect pigmentation in a number of species (17). Appropriate iron concentrations stimulate pigment production in *Penicillium citrinin* (?) (5) and *Torulopsis pulcherrima* (44). In *Fusarium oxysporium* the relation of zinc and iron may control the formation of one or both the red and blue pigments normally present in this species (17).

There is good evidence that at least some bacteria require Fe, Mn, B, and Cu (48). Fe has been reported by Bunting (11) to be necessary for pigmentation in *Serratia marcescens* but Dewey and Roe (14a) reported that Fe was not needed. Waring and Werkman (52) in a careful study found that Fe was necessary for six bacteria including *Serratia marcescens*. In the latter form the critical range of Fe concentration was much narrower than that for growth. Waring and Werkman also found that organisms with a complete cytochrome system required greater amounts of Fe than those having only partial cytochrome systems.

Most reports of the effect of mineral elements on chromogenic organisms have been of a qualitative nature. It is to be hoped that new studies will be made with quantitative estimation of pigment production due to the addition of trace elements so that more specific information may be obtained.

Carbon and nitrogen sources:—It appears that the source of organic carbon is of great importance in pigment production since frequently organic compounds may support growth with little or no coloration (12, 19, 21, 26, 45). In some cases the failure of pigmentation appears to be due to pH changes during growth (26) but generally the unfavorable action has not been explained.

Reference to Table 1, which shows suitable carbon and nitrogen sources for growth and pigmentation of several forms, is indicative of the relatively simple compounds on which various organisms may grow and synthesize pigments. Glycerol is an excellent carbon source for several bacteria and fungi and is evidently metabolized by them. An exception to this, perhaps, is *Bacillus pyocyaneus* which is stimulated to produce pigment by glycerol but the latter is not used in the process (28).

TABLE 1. Some sources of carbon and nitrogen suitable for pigmentation as reported in a few recent studies of chromogenic bacteria and fungi.

Organism	Pigment (if known)	Suitable Carbon Source	Suitable Nitrogen Source	Reference
BACTERIA				
Actinomyces coelicolor	———	glycerol glucose NH^4 acetate	asparagine NH_4 acetate	13 38
A. violaceus ruber	———	glycerol glucose	asparagine	13
Aerobacter sp.	———	glycerol	NH_4 citrate	20
Bacillus pyocyaneus	pyocyanin	glycerol	NH_4 citrate	28
Escherichia sp.	———	glycerol	NH_4 citrate	20
Proactinomyces cyaneus	litmocidin	glucose	tryptone and peptone	19
Pseudomonas aeruginosa	———	glucose	$(NH_4)_2 SO_4$	52
Serratia marcescens	prodigiosin	glucose	$(NH_4)_2 SO_4$	52
Serratia marcescens	prodigiosin	glycerol asparagine	NH_4 citrate NH_4 citrate	11 14a
FUNGI				
aspergillus glaucus series	flavoglaucin auroglaucin rubroglaucin	glycerol glucose sucrose maltose	NH_4 tartrate	21
Coccosporium sp.	———	glucose sucrose	NO_3^-	24
Helminthosporium gramineum	helminthosporin hydroxy-iso-helminthosporin	mannose glucose fructose sucrose maltose starch	NO_3^-	12
Penicillium carmino-violaceum	carviolacin carviolin	glycerol	———	26
P. citrinum?	citrinin	glucose	NH_4 tartrate	5

Several carbon sources of equal value have been reported for *Aspergillus glaucus* spp. and *Helminthosporium gramineum* (Table 1). This conclusion was apparently based on visual comparison. However, in a similar instance Higinbotham and Powers (24) measured pigment concentration photometrically and found distinct differences between glucose and sucrose as carbon sources for *Coccosporium*. Pigmentation was much greater with glucose than with sucrose although this might well have gone undetected visually. Furthermore, sugar concentration optimal for color formation was lower than that giving maximum dry weight.

The nitrogen source may be inorganic for most forms studied (Table 1). The combination of NH_4 and an organic acid appears to chiefly prevent undue acidification of the medium, although it may also act as an additional source of carbon in some cases. Some of the more complex nitrogen sources may give little or no pigmentation (12, 19, 21).

The carbon/nitrogen ratio is an important factor in pigment production with the *Aspergillus glaucus* series (21), *Fusarium coerulium* (35), *Penicillium purpurogenum*, *Paecilomyces* sp., and *Coccosporium* sp. (43). In the latter species it was found that excessively high or low C/N ratios may give appreciably less pigment production than a median C/N ratio. Growth, as measured by dry weight, was less affected by the C/N ratio.

Discussion and Summary

At the present stage little of a conclusive nature may be said of the significance of pigmentation in the bacteria and fungi. Interest has grown in this field recently and now the chemical structure of more than 70 of the pigments has been elaborated. The chemical nature of many of the pigments is such that they potentially could have important functions in metabolism such as hydrogen carriers or respiratory pigments. There is evidence that pyocyanine, phoenicin, and rubrofusarin are active in enzyme systems. It has been suggested that pigments may have a role in development, in determination of sex, and in sexual reproduction and there is some evidence of each of these possibilities. Several pigments have an antibiotic action.

The accumulation of pigments in a number of species indicates that they are products which are not deeply involved in metabolism. Yet this is no criterion of their importance since the cells in which they accumulate are older and less active. Furthermore the studies of pigment production under the influence of various factors shows that pigments accumulate in many cases only in a relatively narrow range of conditions. This is suggestive of alternative metabolic systems under which growth, but not pigmentation, may occur. The precise systems leading to pigment synthesis cannot fail to be significant.

Bibliography

1. Anslow, W. K., and H. Raistrick, 1938. Biochem. J. **32**:2288-9.
2. Aronson, J. D. and I. Alderman, 1943. Jour. Bact. **46**:261-267.
3. Ashley, J. N., H. Raistrick, and T. Richards, 1939. Biochem. J. **33**:1291-1303.
4. Asano, M. and S. Huziwara, 1939. (Chem. Abstr. **34**:1982. 1940).
5. Bailey, J. H., and C. J. Cavallito, 1943. (abstract). Jour. Bact. **45**:30-31.
6. Baker, J. A., 1938. Jour. Bact. **35**:625-631.
7. Birkenshaw, J. H., 1937. Biol. Rev. **12**:357-392.
8. Bose, S. R., 1941. Trans. Nat'l Inst. Sci., India **2(3)**:69-85.
9. Brazhnikova, M. G., 1946. Jour. Bact. **51**:655-657.
10. Brown, W., 1922. Ann. Bot. **36**:257-283.
11. Bunting, M. I., 1940. Jour. Bact. **40**:57-68.
12. Charles, J. H. V., H. Raistrick, R. Robinson, and A. R. Todd, 1933. Biochem. J. **27**:499-511.
13. Conn, J. E., 1943. Jour. Bact. **46**:133-149.
14. Curd, F. H., A. Robertson, and R. J. Stephenson, 1933. J. Chem. Soc. 1933:130-133.

14a. Dewey, B. T., and C. P. Roe, 1943. Jour. Bact. **45**:495-498.
15. Dillon-Weston, W. A. R., 1931. Sci. Agron. **12**:81-87.
16. Emerson, R. and D. L. Fox, 1940. Proc. Roy. Soc., (London)B, **128**:275-293.
17. Foster, J. W., 1939. Bot. Rev. **5**:207-239.
18. Friedhem, E. A. H., 1938. Helv. Chim. Acta **21**:1464-5. (Chem. Abstr. **33**:2170. 1939).
19. Gause, G. F., 1946. Jour. Bact. **51**:649-653.
20. Gilliland, J. R. and R. H. Vaughn, 1943. Jour. Bact. **45**:499-507.
21. Gould, B. S., and H. Raistrick, 1934. Biochem. J. **28**:1640-1656.
22. Gray, W. D., 1938. Amer. Jour. Bot. **25**:511-522.
23. Haxo, F., 1946. (abstract). Amer. Jour. Bot. **33**:835-836.
24. Higinbotham, N., and E. L. Powers, 1947. Amer. Jour. Bot. **34**:483-492.
25. Higinbotham, N., and co-workers. Unpublished (U. Notre Dame).
26. Hind, H. G., 1940. Biochem. J. **34**:67-72.
27. Hoogerheide, J. C., 1944. Bot. Rev. **10**:599-638.
28. Jelinek, B., and T. Hof, 1938. (Chem. Abstr. **33**:6896, 1939.).
29. Kogl, F. and J. Sparenburg, 1940. (Chem. Abst. **35**:5117, 1941).
30. MacCurtin, T. P., and J. Reilly, 1940. Biochem. J. **34**:1419-1421.
31. Mayer, F. and A. H. Cook, 1943. The chemistry of natural coloring matters. Reinhold Publishing Corp., N. Y.
32. McClung, L. S., 1943. Jour. Bact. **46**:507-512.
33. Metz, O., 1930. Arch. Mikrobiol. **1**:197-251.
34. Michaelis, M. and F. S. Thatcher, 1945. Arch. Biochem. **8**:177.
35. Moore, E. S., 1924. Ann. Bot. **38**:137-162.
36. Mull, R. P., and F. F. Nord, 1944. Arch. Biochem. **4**:419-433.
37. Nisakawa, H., 1940. (Chem. Abstr. **34**:6936, 1940).
38. Oxford, A. E., 1946. J. Bact. **51**:267-269.
39. Porter, J. R., 1946. Bacterial chemistry and physiology. John Wiley and Sons, Inc., N. Y.
40. Posternak, T., 1939. (Chem. Abstr. **34**:4096, 1940).
41. Pulselli, A., 1927. (Biol. Abstr. **3**:1661, #17764, 1929).
42. Raistrick, H., 1940. Ann. Rev. Biochem. **9**:571-592.
43. Reilly, D., and co-workers. Unpublished (U. Notre Dame).
44. Roberts, C., 1946. Amer. Jour. Bot. **33**:237-244.
45. Seleen, W. A. and C. N. Stark, 1943. Jour. Bact. **46**:491-500.
46. Sonneborn, T. M., 1942. Cold Spring Harbor Symposia on Quantitative Biology **10**:111-125.
47. Smith, G. M., 1946. Amer. Jour. Bot. **33**:625-630.
48. Stiles, W., 1946. Trace elements in plants and animals. The MacMillan Co., N. Y.
49. Sumner, J. B., and G. F. Somers, 1943. Chemistry and methods of enzymes. Academic Press, Inc., N. Y.
50. Tatum, E. L., 1944. Ann. Rev. Biochem. **13**:667-704.
51. Thom, C. and K. B. Raper, 1945. A manual of the Aspergilli. The Williams and Wilkins Co., Baltimore.
52. Waring, W. S., and C. H. Werkman, 1943. Arch. Biochem., 1:425-433.

Variation in Sporulation in *Trichoderma viride* Pers. ex Fries[1]

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The genus *Trichoderma* was founded in 1794 by Persoon, the first species described being *T. viride*. Some confusion in the nomenclature of this genus arose during the next few years, but Fries reduced to synonomy the names he considered to belong to *T. viride* Pers. ex Fries.

Lindau compiled thirteen names in the genus *Trichoderma* but remarked that all but *T. viride* were doubtful because the method of spore formation was unknown in the other twelve.

The most recent work on the taxonomy of *Trichoderma* was done by Bisby (1) in 1939. Bisby considered *Trichoderma* a monotypic genus, which is in accordance with Persoon and Fries.

The antibiotics gliotoxin and veridin were isolated from strains of *T. viride* by Weindling (4) and Brian et al (2). These antibiotics were obtained from yellow pigment-forming strains. Weindling (5) and others have also demonstrated the toxic action of *Trichoderma* on *Rhizoctonia sp.* and other soil fungi.

During the war, strains of *Trichoderma* were found to be the cause of much deterioration in military equipment in the Southwest Pacific. Isolates have been obtained from shelter halves, tent canvas, pistol belts, synthetic rubber raincoats, and other military items. The Biological Laboratory of the Philadelphia Quartermaster Depot is investigating the industial significance of these observations.

Conidia of the three strains investigated usually germinate in a bipolar manner. The conida at first swell to a globoid form, 6-10 microns in diameter; a germ tube then arises by the extrusion of protoplasm through a pore in the spore wall. A second germ tube, arising in the same manner as the first, but from the opposite side of the spore, soon appears. Usually, however, the second germ tube does not exceed 50 microns. The spore, by the time the second germ tube appears, is globoid in form, thin walled, and hyaline. Within 12 hours vacuolation is evident within the hyphae. Such vacuolation seems to be instrumental to the formation of septations. Conidiophores arise within 48 hours and are not sharply distinct from the vegetative hyphae. The conidiophores are usually branched, sometimes unbranched; the branches are often whorled, arising at approximately 90° from the conidiophore or parent hyphae. Hyphae may terminate in phialides. Young phialides lack a firm wall, but this develops from the base upward. A septum forms at the base as the phialide matures; this septum is perforated by a pore at first but apparently closes soon after the conidia formation. At the time of spore formation, the phialides are bowling pin shaped and arise singly, opposite, or in whorls. Each phialide is surmounted by a head of conidia which are held together by slime. Under conditions of high humidity, conidia

[1] Paper from the Department of Biology of Purdue University.

from two or more phialides, may coalesce to form a common head, or they may form in a catenate manner (Plate I).

Conidia arise by the extrusion of protoplasm through the neck of the phialide. After developing a firm wall, each conidium is cut off from the apex of the phialide. With the formation of the next conidium, the mature conidium is forced from the phialide into the slime ball that has formed at the apex of the phialide. The slime ball may increase in size until it contains several hundred spores.

Chlamydospores are intercalary or terminal; constrictions, 6-10 microns apart, form in vegetative hyphae; a large vacuole appears between the constrictions; the delimited area swells and round off, and a heavy wall then forms. Upon germination, chlamydospores give rise to vegetative hyphae that develop into colonies similar to the parent culture.

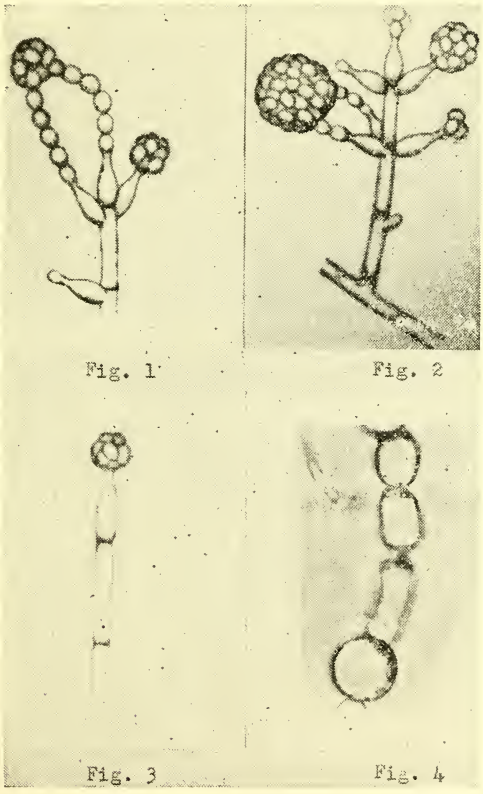

PLATE I. Variation in sporulation in *T. viride*.

Fig. 1, spores borne in a catenate manner. Fig. 2, spores from two phialides coalesce. Fig. 3, spores borne terminally on an unbranched conidiophore. (Figures 1, 2, and 3 are semidiagrammatic drawings.) Fig 4, chlamydospore formation. (Photomicrograph.)

Under conditions of high humidity, the typical *Trichoderma* habit of sporulation is variable. The sporulating habit is normally described as, viz. (1), "conidiophore branched, phialides bearing terminally the conidial heads." Under conditions of high humidity (94-96%), the spores from two or more phialides may coalesce to form a single spore mass that is held together by slime. This is an important taxonomic characteristic of the genus *Gliocladium*. Also the spores may be borne in a catenate manner, or terminally on an unbranched conidiophore, the later is a *Cephalosporium* characteristic. However, if observations are made on cultures grown in a culture chamber of about 50 per cent relative humidity, the typical *Trichoderma* sporulation habit is obtained.

Moist chambers were prepared for this work in the manner described by Spencer (3).

The finding reported in this paper supports, in part, the finding of Bisby (1) on spore formation and variation in *Trichoderma viride* Pers. ex Fries.

References

1. Bisby, G. R. *Trichoderma viride* Pers. ex Fries, and notes on Hypocrea. Transactions of the British Mycological Society, 23 : Part II, 1939.

2. Brian, P. W., P. J. Curtis, H. G. Hemming, and J. C. McGowan. The Production of Viridin by Pigment-forming Strains of *Trichoderma viride*. The Annals of Applied Biology, **33**:190-200, 1946.

3. Spencer, H. M. Laboratory Methods for Maintaining Constant Humidity. International Critical Tables, **1**:67-69. New York and London. 1926.

4. Weindling, R. The Isolation of a Toxic Substance from the Culture Filtrates of *Trichoderma* and *Gliocladium*. Phytopathology, **27**:1175-1177, 1937.

5. Weindling, R. *Trichoderma lignorum* as a Parasite of other Soil Fungi. Phytopathology, **22**:837, 1932.

Myxomycetes New or Rare in Indiana

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Since publication of the first paper on Indiana Myxomycetes (Gray, 1936) the project, which was at first concerned only with the myxomycetes of Clark County, has been expanded to include a survey of the entire state. The present paper constitutes the first report on the expanded project.

With few exceptions the specimens of earlier Indiana collectors have been unavailable, and hence the starting point has been merely a composite list of the species reported by these workers; it is to be hoped that this list will be eventually supplanted by properly labelled herbarium specimens of the various Indiana forms. Collections have thus far been made in twenty-nine counties and from these collections much data has already been gained concerning the relative abundance of various species in the state. The present report is concerned with species not hitherto reported for Indiana or species collected infrequently enough that they should receive some comment. Species being reported for the first time are marked with asterisks; all specimens are deposited in the DePauw University Herbarium under the numbers herein listed:

* *Arcyria occidentalis* (Macbr.) G. Lister

A single specimen (W8108 from Putnam County) forms the basis for the first report of this species from Indiana. Superficially it resembles a rather yellowed fruiting of *Arcyria cinerea* (Bull.) Pers.

* *Badhamia rubignosa* (Chev.) Rost.

Members of the genus Badhamia apparently are not abundant in the state as is evidenced by the reports of earlier workers and by the writer's own collecting experience. Hagelstein (1944) states that this species is common and abundant throughout continental North America, and Macbride and Martin (1934) describe it as probably the most common *Badhamia* in North America; however, our only Indiana specimen is a large fruiting (W3008) taken in Jasper County. The species is not inconspicuous and cannot be easily overlooked so it would seem that perhaps it is not so abundant in Indiana as in other states.

Badhamia utricularis (Bull.) Berk.

This species has been reported twice from Indiana: first by Underwood (1894) from Putnam County and again by Gray (1936) from Clark County. Because of the paucity of Badhamias in the state, a third collection is herein reported. It is interesting

[1] Paper from the Department of Botany, The Ohio State University, No. 502.

to note that this collection (No. 122) was made in Putnam County at Fern, which was one of the regions explored earlier by Underwood. It is quite possible that Underwood's early report was based on a specimen taken from the same region as No. 122.

**Clastoderma Debaryanum* Blytt

Our only representative of this species is a fruiting (GWM5398) which Dr. G. W. Martin obtained by placing forest litter from Clark County in a moist chamber. Judging from its distribution as reported by Hagelstein (1944) and Macbride and Martin (1934) it is to be expected in Indiana although probably not in abundance.

Comatricha pulchella (Bab.) Rost.

Hitherto represented by only two reports (Thomas, 1901 and Gray, 1939) a third collection of this species is now reported. This third report is based on No. 300 which was collected in Decatur County.

Craterium leucocephalum (Pers.) Ditm.

The genus Craterium, in which Macbride and Martin recognize seven species, thus far has been represented in Indiana by reports of but two species. Olive (1898) and Barbazette (1909) both reported *C. leucocephalum* from Indiana and Mutchler (1903) reported this species in addition to *C. cylindricum* Massee. Due to the paucity of records for this species it seems worthwhile to report five collections made by the writer in Ripley County and one by Dr. Martin in Clark County. Species of *Craterium* are not easily overlooked and hence it would appear that such species are not comon in this region. This is substantiated in part by the observations of Mr. William Botts, who collects in northern Kentucky and has noted the infrequent occurrence of Crateriums. (Nos. 593, 608, 618, 621, 634, and GWM 5631)

Cribraria elegans Berk. & Curt.

This delicate Cribraria, first reported from Clark County (Gray, 1939), has since been collected in Scott County (No. 156) and Decatur County (No. 306).

Cribraria minutissima Schw.

This species was reported first by Mutchler (1903) from the Lake Winona region and again by Barbazette (1909) from Northern Indiana. Two additional reports of the species are hereby made; these are based on specimens Nos. 5450 and 5478 obtained in moist chambers by Dr. Martin on material gathered in Clark County.

**Didymium minus* Morgan

Regarded by Hagelstein and also by the Listers as only a variety of *D. melanospermum* (Pers.) Macbr., this species is represented

by a single collection (No. 625) from Ripley County. It is to be expected in the eastern part of the state, since it was reported by Morgan (1894) from the Miami Valley, Ohio.

Didymium xanthopus (Ditmar) Fr.

No. 628 from Ripley County is this species and represents the second report for Indiana since Mutchler also reported it in 1902. Lister (1925) regarded this form as only a variety of *Didymium nigripes* (Link) Fr., and Hagelstein (1944) remarked that he regarded it as a species somewhat reluctantly. I am of the opinion that it is a distinct species, since I have grown both *D. nigripes* and *D. xanthopus* from spore material supplied by Mr. Hagelstein and noted rather marked differences between the two. *D. nigripes* forms a colorless plasmodium whereas *D. xanthopus* forms a cream-colored one when grown on carrot decoction agar. Under identical conditions, plasmodia of *D. xanthopus* are far more vigorous growing than those of *D. nigripes* and several times it has been possible to obtain large amounts of plasmodium of the former by growing it on rolled oats in a moist chamber using the method devised by Camp (1936). Martin (The Myxomycetes, North American Flora; in press) has also noted differences between these two forms with regard to plasmodial colors and states that the plasmodium of *D. nigripes* is "gray or colorless" while that of *D. xanthopus* is "yellowish white, pale flesh-color, rose or green". It is quite true that caution should be exercised in the use of plasmoidal color as a criterion of species; however, when two forms consistently exhibit a difference under similar culture conditions, it seems obvious that the difference is a real one.

**Echinostelium minutum* de Bary

There is no report of a field collection of this species from Indiana. Since it is the smallest species of myxomycete (sporangia 40-50 microns in diameter), it is easily overlooked in the field. This report of the species is based on Dr. Martin's No. 5477 which developed in a moist chamber on litter from Harrison County.

**Enerthenema papillatum* (Pers.) Rost

As with *Echinostelium minutum* there is no record of a field collection of this species in Indiana. Dr. Martin's No. 5467, which developed in a moist chamber on litter from Harrison County, is this species.

**Hemitrichia abietina* (Wig.) Lister

Represented by two collections thus far: one (No. W5638) from Putnam County, the other (No. W5821) from Montgomery. Both collections were from decaying wood and on first appearance resemble weathered fruitings of *Arcyria deundata* (L.) Wettstein.

Lamproderma violaceum (Fries) Rost.

Lamproderma arcyrionema Rost. seems to be our most abundant Indiana species of Lamproderma. *L. violaceum* was reported once by Underwood (1894), presumably from Putnam County; another collection (Wa 782) is herein reported from the same county.

**Licea pusilla* Schrad.

This species is apparently infrequently collected, since Hagelstein lists it only for Pennsylvania, whereas Macbride and Martin list it for North Carolina, Iowa, and Europe. We have a single specimen (Martin 5451), which developed in a moist chamber on litter from the Clark County State Forestry.

**Lycogala conicum* Pers.

Only one collection has thus far been made in Indiana of this rare species—No. 313 taken in Decatur County in August, 1938. A portion of the fruiting was sent to the late Mr. Hagelstein who reported it in Mycologia in 1939. This report completes our observations on the occurrence of the genus *Lycogala* in Indiana, since all four species have now been reported for the state. Indiana specimens of *Lycogala flavofuscum* (Ehr.) Rost. have not been seen by the writer; however, the species is unmistakeable and has been reported by Underwood (1894), Thomas (1901), Mutchler (1902 and 1903), and Van Hook (1916).

* *Mucilago spongiosa* var. *solida* STURGIS

Mucilago spongiosa (Leyss.) Morg. has been recorded two times for Indiana, but there is no previous report of this variety. Hagelstein states that the variety is not infrequent wherever the species occurs in abundance. (320; Floyd County).

**Physarum penetrale* Rex

The elongated sporangium and long columella of this species make it easily recognized. The present report is based on a single somewhat weathered collection, No. 488 from Harrison County. Macbride and Martin regard the species as cosmopolitan but not common in North America.

**Physarum viride* var. *incanum* Lister

Physarum viride (Bull.) Pers. has been collected in the state frequently; however, we have only one collection of var. *incanum* (W3024; Marshall County).

Stemonitis carolinensis Macbr.

This species was earlier reported by Mutchler (1903) and Van Hook (1916). Two additional collections have been made: No. 130 from Harrison County and No. 142 from Floyd County.

**Stemonitis flavogenita* Jahn

Hitherto unreported for the state, this species has been collected twice—once in Clark County (No. 50) and once in Harrison

County (No. 60). Both specimens were found on decaying wood, which is in agreement with Macbride and Martin's statement that such a substratum is its main habitat.

Stemonitis virginiensis Rex.

This species, while not included in a list of Stemonitis species prepared by Whetzel (1902), was reported once by Mutchler (1903). It seems worthwhile to note that we now have seven collections of the species from Indiana: one from Clark County, two from Washington County, and four from Orange County (Nos. 188, 418, 419, 420, 421, 434, 436.).

Acknowledgments

The writer is indebted to the Indiana Academy of Science for a research grant which defrayed in part the expenses of collecting. Acknowledgment is also made of the aid of Dr. G. W. Martin, not only for sharing portions of his southern Indiana collections but also for the determination of doubtful forms. Thanks are also due Dr. Winona H. Welch who has sent me all of her myxomycete collections, and to the late Mr. Robert Hagelstein, who was always so generous in supplying material for comparison.

Literature Cited

Barbazette, L. 1909. Tentative list of myxomycetes of northern Indiana and southern Michigan. The Amer. Midl. Nat. **1**:38-43.

Camp, W. G. 1936. A method of cultivating myxomycete plasmodia. Bull. Torrey Bot. Club **63**:205-210.

Gray, W. D. 1936. Myxomycetes of Clark County, Indiana. Proc. Ind. Acad. Sci. **45**:69-73.

———. 1939. Myxomycetes of Clark County, Indiana, II. Proc. Ind. Acad. Sci. **48**:71-73.

Hagelstein, R. 1939. Notes on the mycetozoa-III. Mycologia **31**-337-349.

———. 1944. The mycetozoa of North America. Lancaster Press, Lancaster, Pa.

Lister, A. 1925. A monograph of the mycetozoa. British Museum Publ. (Rev. by G. Lister).

Macbride, T. H. and Martin, G. W. 1934. The myxomycetes. Macmillan, New York.

Martin, G. W. The Myxomycetes; North American Flora (in press).

Morgan, A. P. 1894. The Myxomycetes of the Miami Valley, Ohio. Jour. Cin. Soc. Nat. Hist. **16**:127-156.

Mutchler, F. 1902. A collection of myxomycetes. Proc. Ind. Acad. Sci. 1901:291-292.

———. 1903. Myxomycetes of Lake Winona. Proc. Ind. Acad. Sci. 1902:115-120.

Olive, E. W. 1898. A list of the mycetozoa collected near Crawfordsville, Indiana. Proc. Ind. Acad. Sci. 1897:148-158.

Thomas, M. B. 1901. Cryptogamic collections made during the year. Proc. Ind. Acad. Sci. 1900:121-123.

Underwood, L. M. 1894. Report of the Botanical Division of the Indiana State Biological Survey. Proc. Ind. Acad. Sci. 1893:13-67.

Van Hook, J. M. 1916. Indiana fungi III. Proc. Ind. Acad. Sci. 1915: 141-148.

Whetzel, H. H. 1902. Notes on the genus Stemonitis. Proc. Ind. Acad. Sci. 1901:261-266.

Higher Fungi of Marion County, Indiana

J. O. Cottingham, Indianapolis

In submitting this list of the fleshy, leathery and woody fungi of Marion County, Indiana, I realize that mycologists will note many species missing which are probably indigenous to this vicinity. No doubt many species will be added to my list in the future. It will be noted that the entire genus Lactarius and others are missing.

For the past two years many members of the Nature Study Club of Indiana have been assisting me in finding and identifying mushrooms. Especially would I mention Mr. William A. Myers of Indianapolis. I thank Dean Ray C. Friesner of Butler University for his assistance and Dr. Clyde M. Christensen of the University of Minnesota who personally identified twenty specimens that I sent to him. They all have my appreciation and gratitude.

In making identifications I used the works of Graham, McIlvain, Christensen, Atkinson, Gussow and Odell, Marshall, Gibson, Hard and Kreiger.

Agaricaceae

White Spored Forms: *Amanita muscaria* Fr. *A. phalloides* Fr. *A. spreta* Pk. *Amanitopsis adnata* Smith *A. vaginata* Fr. *Armillaria mellea* Fr. *Catharellus aurantiacus* Fr. *C. cibarius* Fr. *Clitocybe adirondackensis* Pk. *C. gigantea* Fr. *C. illudens* Schw. *C. infundibuliformis* Fr. *C. monadelpha* Morgan *C. multiceps* Pk. *C. nebularis* Fr. *C. ochropurpurea* Berk. *Collybia acervatia* Fr. *C. confluens* Fr. *C. dryophila* Fr. *C. longipes* Fr. *C. platyphylla* Fr. *C. radicata* Fr. *C. velutipes* Fr.

Hygrophorus borealis Pk. *H. ceraceous* Fr. *H. eburneus* Fr. *Lenzites betulina* Fr. *L. sepiara* Fr. *Lepiota acutaesquoamosa* Fr. *L. americana* Pk. *L. caerulescens* Pk. *L. cristata* Fr. *L. Morgani* Pk. *L. naucina* Fr. *L. procera* Fr. *Marasmius oreades* Fr. *M. peronatus* Fr. *M. rotula* Fr. *M. urens* Fr. *Mycena galericulata* Fr. *M haematopa* Fr. *M. leajana* Berk.

Panus rudis Fr. *P. tortulosus* Fr. *Pleurotus applicatus* Fr. *P. ostreatus* Fr. *P. petaloides* Fr. *P. pubescens* Pk. *P. sapidus* Kalchb. *P. ulmarius* Fr. *Russula atropurpurea* Maire *R. delica* Fr. *R. emetica* Fr. *R. foetens* Fr. *R. Mariae* Pk. *R. ochrophylla* Pk. *R. purpurina* Q. & S. R. *rosipes* Bres. *R virescens* Fr. *Schizophyllum commune* Fr. *Tricholoma personatum* Fr. *T. transmutans* Ph.

Pink Spored Forms: *Claudopus nidulans* Fr. *Clitopilus noveboracensis* Ph. *prunulus* Fr. *Entoloma grande* Pk. *E. lividum* Fr. *E. rhodopolium* Fr. *Leptonia sp. nov. *Pluteus cervinus* Schaeff. *P. cervinus*, var. *alba*. *P. longistriatus* Pk. *Volvaria bombycina* Fr.

Brown Spored Forms: *Bolbitius tener* Fr. *Cortinarius cinnabarinus* Fr. *C. cinnamomeus* Fr. *C. distans* Pk. *C. ochraceus* Pk. *Crepidotus fulvo-*

tomentosus Pk. *C. versutus* Pk. *Galera crispa* Longyear *Hebeloma album* Pk. *Naucoria semiorbicularis* Fr. *Pholiota adiposa* Fr. *P. aggericola* Pk. *P. destruens* Fr. *P. dura* Bolt *P. praecox* Fr. *P. squarrosoides* Pk.

PURPLE-BROWN SPORED FORMS: *Agaricus campestris* Fr. *A. magnificus* Pk. *A. placomyces* Pk. *A. Rodmanii* Pk. *A. silvicola* Vitt. *Hypholoma appendiculatum* Fr. *H. incertum* Pk. *H. perplexum* Pk. *H. sublateritium* Fr. *Stropharia semiglobata* Fr.

BLACK SPORED FORMS: *Anellaria separata* Karst. *Coprinus atramentarius* Fr. *C. comatus* Fr. *C. deliquescens* Fr. *C. domesticus* Fr. *C. ephemerus* Fr. *C. fimentarius* Fr. *C. micaceus* Fr. *Panaeolus solidipes* Pk. *Psathyrella disseminata* Fr.

Clavariaceae: *Clavaria aurea* Fr. *C. cinerea* Bull. *C. circinans* Pk. *C. cristata* Fr. *C. pyxidata* Pers. *C. tetragona* Schw.

Hydnaceae: *Hydnum caput-Medusae* Bull. *H. caput-ursi* Fr. *H. coralloides* Scop. *H. septentrionale* Fr. *Odontia ferruginea* Pers., or *Hydnum crinale* Fr.

Tremellaceae: *Hirneola auricula-Judae* Berk. *Tremella lutescens* Pers. *T. mycetophila* Pk.

Telephoraceae: *Craterellus cantharellus* Schw. *Stereum fasciatum* Schw. *S. pergamenum* Berk. & Curt. *Thelephora Schweinitzii.*

Polyporaceae: *Boletinus pictus* Pk. *B. porosus* Pk. *Boletus auriporus* Pk. *B. edulis* Bull. *B. felleus* Bull. *B. separans* Pk. *Daedalea ambigua* Berk. *D. confragosa* Fr. *D. unicolor* Fr. *Favolus canadensis* Klotsch *Fomes applanatus* Pers. *F. fomentarius* Gill. *F. lobatus* Schw. *Merulius rubellus* Pk. *Polyporus aboluteus* Pk. *P. arcularius* Fr. *P. biennis* Christensen *P. biformis* Klotzsch *P. brumalis* Fr. *P. cinnabarinus* Fr. *P. circinatus* B. & C. *P. conchifer* Schw. *P. cristatus* Fr. *P. floriformis* Quel. *P. giganteus* Fr. *P. gilvus* Schw. *P. hirsutis* Fr. *P. hispidus* Bull. *P. lucidus* Fr. *P. osseus* Kalchb. *P. perennis* Fr. *P. picipes* Fr. *P. planellus* Murr. *P. pubescens* Fr. *P. radicatus* Schw. *P. resinosus* Fr. *P. Rheades* Fr. *P. Spraguei* B. & C. *P. sulphureus* Fr. *P. tulipiferus* Schw. *P. versicolor* Fr. *Poria ambigua* Bres. *P. nigra* Berk.

Phallaceae: *Phallus impudicus* Fr.

Nidulariaceae: *Cyathus vernicosus* Bull.

Lycoperdaceae. *Calvatia caelata* Bull. *C. craniiformis* Schw. *C. cyathiformis* Bosc. *Lycoperdon gemmatum* Batsch *L. pyriforme* Schaeff. *L. Wrightii* B. & C. *Geaster triplex* Jungh.

Helvallaceae: *Gyromitra brunnea* Under. *Morchella bispora* Sorok. *M. conica* Pers. *M. crassipes* Vent. *M. deliciosa* Fr. *M. esculenta* Pers. *M. semilibera* D. C.

Pezizaceae: *Bulgaria rufa* Schw. *Patella scutellata* Morg. *Peziza badia* Pers. *P. coccinea* Jacq. *Urnula craterium* Fr.

Xylariaceae: *Daldinia concentrica* Nolt *Xylaria polymorpha* Pers.

* The Leptonia listed was found more than two years ago and specimen was sent to Dr. Christensen for identification. He stated that it was a Leptonia but did not know the species. Following is a description: Pileus reddish brown, 37 mm, glabrous, eccentric. Lamellae brown, adnate or adnexed. Stipe brown, 50 mm. long. Spores reddish brown, angular. No annulus. No volva. They grew at base of stump, caespitose, about twenty in a cluster, and every pileus was very eccentric to the stipe. Can find no reddish brown spored species of that description. In view of this fact, I believe it should be classified as a new species.

Virginia Pine *(Pinus virginiana)* in Southern Indiana

DANIEL DENUYL, Purdue University

The original distribution of Virginia pine in Indiana is defined by Deam[1] who made a study of its distribution. In his book, "Trees of Indiana", he states that, "The distribution in Indiana is quite limited, and has never been understood by authors who variously give it as found throughout the southern part of Indiana. It is confined to the knob area of Floyd, Clark and Scott Counties, and the southeastern part of Washington County. In the original forest it is confined to the tops of the knobs where it is associated with Quercus prinus. It propagates easily from self sown seed, hence is soon found on the lower slopes of cut-over lands, and soon occupies fallow fields. It is now found in the open woods several miles east of the knobs in the preceding counties, but pioneers of this section say it was not a constituent of the original forests but has come in since the original forests were heavily cut over. It is believed that it crowned the knobs over our area from 5-10 miles wide extending through the counties named and extending northward about 25 miles. This species is found in the open woods on a few hills on the Millport Ridge in the northern part of Washington County, and it appears as if native, but investigation showed that it had spread from a tree on the site of a pioneer's cabin. It is also found as a frequent escape on the wooded bluff of Raccoon Creek in the southern part of Owen County, and appears as native here. It is associated on the bluff and slope with hemlock".

A study of the present distribution of Virginia pine shows it to be much more widely distributed than that reported by Deam. Its range has been extended through planting because it was commonly planted on farmsteads, school and church grounds in southern Indiana and from these planted trees natural regeneration has occurred.

One of the best examples of natural regeneration from a planted tree is that reported for Monroe County by Potzger.[2] His study showed that from a tree planted about 1860 a naturally established stand of pine has developed on an abandoned orchard site. Other similar occurrences have been observed in southern Indiana.

During the past 10 years Virginia pine has been used for reforestation purposes. This use has also extended its distribution since natural regeneration from planted trees is sometimes encountered.

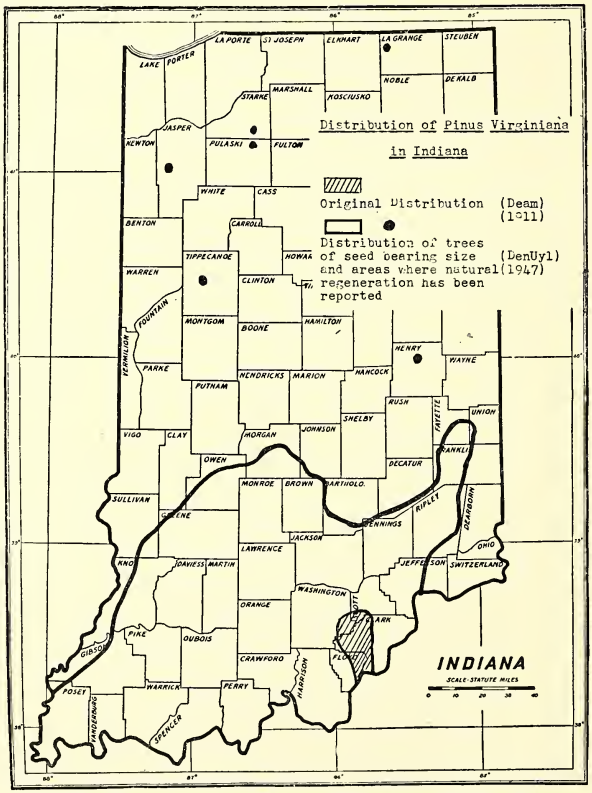
The growth characteristics that it exhibits under southern Indiana conditions are best illustrated by describing what has taken place on the Clark State Forest.

[1] Deam, C. C. (1921) Trees of Indiana, Publication 13, Department of Conservation, State of Indiana.

[2] Potzger, J. E. (1931) Some observation on *Pinus virginiana* Mill. in Monroe County, Indiana. Proc. Ind. Acad. Sci. Vol. 44.

In 1929, a timber cruise covering a portion of the Clark State Forest was made. At that time Virginia pine was a common associate of the mixed hardwoods. The total number of hardwoods and pine ranged from 80 to 250 trees per acre over 4 inches in diameter. Of this total, Virginia pine comprised from 8 to 50 stems per acre and varied in size from 4 to 16 inches in diameter.

In 1946, a cruise of this same area showed Virginia pine still present with approximately the same number of stems per acre. On some portions of the area Virginia pine trees over 14 inches in diameter had been cut prior to 1946. If these trees are added to the number



present in 1946, it indicates that the percentage of Virginia pine had increased during the 17-year period. In addition to the 1929 timber cruise, sample plots to study the growth of Virginia pine were established. These plots were located on a portion of the State Forest where the pine occurred in a pure stand. A brief summary of the establishment and growth of the pine on this area will serve to illustrate some of its growth characteristics.

The land was farmed for a few years and about 1905 it was abandoned. A few years later the eroded old field was acquired by the State of Indiana and made part of the Clark State Forest. The record of this area prior to 1929 shows that Virginia pine invaded this old field and at the time the field was abandoned it supported a few pine trees of seed bearing size.

In 1929, the stand of pine consisted of trees 2 to 14 inches in diameter and numbering approximately 500 stems per acre. The average age of the stand was 20 years indicating that most of the trees became established about 1910. There were a few hardwood trees in mixture with the pine which consisted principally of sassafras.

Remeasurements of the sample plots in 1946 show that the stand per acre averaged 375 trees ranging in size from 3 to 16 inches. The growth of the pine during this 17-year period averaged 1 cord per acre annually. In this stand the Virginia pine has developed into a tree with a tall thin bole, few side branches, thin, shade-developed foliage and a small crown. The total height of the trees varies from 70 to 90 feet. An understory of hardwoods has become established with trees ranging in size from seedlings to trees 3 inches in diameter.

The studies on the Clark State Forest also show that during the past 17 years Virginia pine has invaded areas where it formerly did not occur. It is now found invading many of the old hardwood planting areas such as the 1913 sycamore plantation. On other areas where other species of pine have been planted and a fair to good stand has become established, Virginia pine is also invading those plantations. An example is tract 119 where a mixture of 6 pines and black locust were planted in 1937. In this plantation Virginia pine has seeded in naturally and in some places has outgrown the planted pines. On the eroded portions where black locust was planted but which has not grown very well, Virginia pine has come in the more open areas and there it is growing very rapidly.

On some portions of the forest newly established Virginia pine consists of seedlings 4 to 30 inches in height and numbering from 15 to 25 thousand per acre. Other areas support scattered trees of seed bearing size and as the hardwood stands thin out seedlings of pine became established.

The characteristics which have been described for Virginia pine on the Clark State Forest are also applicable to the species when found growing in other parts of Indiana. It exhibits the same aggressiveness in invading abandoned fields and its growth habits are like those that have been described.

From the studies of Virginia pine on the Clark State Forest and supplemented by investigations covering other portions of Indiana, it is apparent that during the past few decades the range of Virginia pine has been extended. The species has the following characteristics:

1. It is an aggressive species and establishes itself easily from self sown seed.

2. It is an early seed producer with 5-year old trees producing good cone crops.

3. It is a rapid grower compared to other pines that are used for reforestation purposes.

4. It has reached its best development on portions of the Clark State Forest, where it has grown very well in mixture with native hardwoods.

Indiana Plant Distribution Records, VIII. 1947

This is a continuation of the annual reports intended to keep Deam's "Flora of Indiana" up to date. The present report comprises two sections, viz. "Species," giving new county records with location of confirming specimens; and "Nomenclatorial Changes" in which an attempt is made, within the limits and in the spirit of conservative taxonomy to keep the "Flora" up to date in plant names.

Species

Genera are listed in the order used in the "Flora" and species are given in alphabetical order within the genera. Symbols following the county indicate the herbaria in which confirming specimens have been deposited. Entities new for the state are given in bold face and cases of doubt whether a species, newly found within the state, will become a part of the state flora are preceded by an asterisk.

The specimens listed below have been collected by the following collectors: Ball State Teacher's College (BS): Mrs. Marion Rector; Butler University (B): Esther Bower, C. C. Deam, Ray C. Friesner, John E. Potzger and F. A. Swink: Chicago Natural History Museum (Field Museum) (F): H. H. Smith; Deam Herbarium (D): C. C. Deam, R. C. Friesner; Huntington College (Hu): Fred Loew: U. S. National Herbarium (N): H. W. Clark, J. E. Potzger, J. T. Scovell.

The committee maintains a card file showing published distribution of each species within the state. Botanical workers needing such information may obtain distribution maps of any species recorded in the Flora, or subsequently added in these reports, by requesting same from the secretary of this committee.

Botrychium dissectum v. *obliquum*, Jennings (B). *Osmunda cinnamomea*, Delaware (BS). *Cystopteris fragilis* v. *protrusa*, Clay (B). *Pteretis pensylvanica* f. *pubescens*, Delaware (BS). *Dryopteris spinulosa*, Clay (B). *Athyrium angustum*, Clay (B). *Equisetum arvense*, Clay (B). *Juniperus virginiana* v. *crebra*, Franklin (B). *Potamogeton strictifolius* var. *rutiloides*, Kosciusko (D). *Alisma subcordatum*, Wayne (D).

Festuca elatior, De Kalb (B). *F. obtusa*, Clay (B), Union (B). *F. rubra*, Owen (B). *Bromus commutatus*, Brown (B), Orange (B). *B. inermis*, Franklin (B). *B. japonicus* Clay (B), Union (B). *B. latiglumis*, Clay (B). *B. secalinus*, Brown (B). *B. tectorum*, Union (B). *Poa chapmaniana*, Dubois (B), Jennings (B). *P. compressa*, Union (B). *P. trivialis*, De Kalb (D). *Eragrostis frankii*, Franklin (B). *E. spectabilis*, Franklin (B). *E. hypnoides*, Clark (D,B). *Diarrhena americana*, Franklin (B). *Dactylis glomerata*, Clay (B). *Melica nitens*, Crawford (D). *Agropyron repens*, Clay (B). *Elymus canadensis*, Clay (B). *E.*

riparius, Decatur (B). *E. villosus*, f. *arkansanus*, Clay (B). *E. v.* v. *australis*, Clay (B). *E. virginicus* v. *glabriflorus*, Hendricks (B).

Hystrix patula, Clay (B), Randolph (B,D), Union (B). *Hordeum jubatum*, Orange (B). *Sphenopholis nitida*, Clay (B). *S. obtusata*, Jasper (B). *Danthonia spicata*, Clay (B). *Agrostis alba*, Union (B). *A. perennans*, Decatur (B). *Phleum pratense*, Clay (B). *Muhlenbergia mexicana*, Gibson (B), White (B). *M. schreberi*, Daviess (B). *M. sylvatica*, Lake (B). *Sporobolus clandestinus*, White (B). *S. vaginiflorus*, Franklin (B). *Brachyelytrum erectum*, Clay (B), Orange (B). *Aristida dichotoma*, Clay (B). *A. longespica*, Ripley (B). *A. oligantha*, Franklin (B). *Leptochloa filiformis*, Clark (D,B). *Phalaris arundinacea*, Jasper (B).

Paspalum circulare, Ripley (B). *P. pubescens*, Franklin (B). *Panicum addisonii*, Lake (B). *P. agrostoides*, Ripley (B). *P. albemarlense*, Lake (B). *P. boscii*, Clay (B). *P. clandestinum*, Orange (B), Pulaski (D). *P. dichototomum*, Clay (B). *P. huachucae*, De Kalb (D), Lake (B), Orange (B), Union (B). *P. h.* v. *fasciculatum*, Clay (B). *P. latifolium*, Clay (B), Franklin (B). **P. ovale** Ell. Hitchcock, Grasses of United States, p. 639. Collected by J. E. Potzger and C. C. Deam. Jasper (B,D,N), Pulaski (D). *P. philadelphicum* Franklin (B). *P. sphaerocarpon*, Clay (B). *P. tennesseense*, Clay (B), Jasper (B), Putnam (B). *Echinochloa crus-galli*, Ripley (B). *Setaria viridis*, Clay (B). *Sorghum halepense*, Clark (D). *Sorghastrum nutans*, Franklin (B).

Scirpus subterminalis, Kosciusko (D), Marshall (N). *Carex grayii* v. *hispidula*, Adams (D). *C. intumescens* v. *fernaldii*, Fulton (D,B). *Arisaema atorubens*, Clay (B). *A. dracontium*, Clay (B). *Juncus biflorus*, Clay (B), Ohio (B). *J. tenuis*, Pulaski (D,B). *J. tenuis* v. *dudleyi*, Starke (D). *Allium canadense*, Clay (B), Delaware (BS). *Lilium michiganense*, Orange (B), Pulaski (D). *Asparagus officinalis*, Clay (B). *Smilacina racemosa* v. *cylindrata*, Clay (B). *S. r.* v. *typica*, Clay (B). *Maianthemum canadense* v. *interius*, Pulaski (D). *Trillium flexipes*, Delaware (BS). *Smilax ecirrhata*, Delaware (B). *Smilax herbacea* v. *lasioneura*, Clay (B). *S. hispida*, Clay (B). *Dioscorea quaternata*, Clay (B). *Cypripedium calceolus* v. *pubescens*, Dearborn (B), Franklin (B). *Habenaria lacera*, Monroe (B). *H. peramoena*, Clay (B). *Spiranthes cernua*, Daviess (D), Jennings (B). *Aplectrum hyemale*, Dearborn (B).

Populus deltoides, Clark (D), De Kalb (D). *P. heterophylla* (D,Hu). *Salix humilis*, Franklin (B). *Carya cordiformis*, Clay (B). *C. ovalis*, Clay (B). *C. ovata*, Clay (B). *Ostrya virginiana*, Clark (D). *O v.* f. *glandulosa*, *Clay* (B). *Quercus alba*, *Allen* (D,B). *Q. jackiana*, Allen (D,B). *Celtis occidentalis* v. *crassifolia*, Gibson (B), Steuben (D). *Morus alba* v. *tatarica*, De Kalb (B). *Laportea canadensis*, Bartholomew (B), Clay (B). *Boehmeria cylindrica*, Bartholomew (B).

Asarum canadense, Clay (B). *Aristolochia serpentaria*, Clay (B). *Rumex acetosella*, Clay (B). *R. altissima*, Adams (D). *R. crispus*, Clay (B). *R. obtusifolius*, Clay (B). *R. orbiculatus*, Clay (B), Ripley (B).

Polygonum convolvulus, Clay (B). *P. dumetorum*, Clark (D). **P. laxiflorum** Weihe Rhodora 19: 133. 1917. Collected by Huron H. Smith. Madison (F). *P. neglectum*, Delaware (BS). *P. persicaria*, Delaware (BS). *P. scandens*, Steuben (D). *P. virginianum*, Clark (D), Clay (B), Delaware (BS). *Chenopodium album*, Union (B). *Amaranthus graecizans*, Steuben (D). *A. hybridus*, Steuben (D). *A. spinosus*, Clark (D), Franklin (B). *Oxybaphus nyctagineus*, Clay (B).

Claytonia virginica, Lake (B,D). *Cerastium vulgatum* v. *hirsutum* f. *glandulosum*, Clay (B), Delaware (BS). *Arenaria serpyllifolia*, Clay (B), Porter (B). **Spergularia rubra**, (L.) J. & C. Presl. Flora, p. 1045. Collected by C. C. Deam and R. C. Friesner. La Porte (B,D). *Silene antirrhina* Clay (B), Pulaski (D). *S. cserei*, Clay (B). *S. stellata*, Clay (B). *S. s.* v. *scabrella*, Clay (B). *Lychins alba*, Delaware (BS). *Saponaria officinalis*, Clay (B). *Hydrastis canadensis*, Clay (B), Delaware (BS). *Actaea pachypoda*, Clay (B). *Delphinium tricorne*, Delaware (BS). *Myosurus minimus*, Knox (B,D). *Ranunculus abortivus*, Dubois (B). *R. ambigens*, Wayne (D). *R. hispidus*, Gibson (B), Knox (B).

Podophyllum peltatum, Lake (D). *Menispermum canadense*, Delaware (BS). *Liriodendron tulipifera*, Clay (B). *Sassafras albidum*, Clay (B), De Kalb (D). *Lepidium campestre*, La Porte (B,D). *L. virginicum*, Delaware (BS). *Arabidopsis thaliana*, Jackson (B). *Brassica juncea*, Clay (B). *B. kaber* v. *pinnatifida*, Clay (B). *Barbarea vulgaris* v. *arcuata*, Clay (B), Harrison (B). *Iodanthus pinnatifidus*, Delaware (BS). *Cardamine douglassi*, Knox (B). *Rorippa sessiliflora*, Clark (D). *Camelina microcarpa*, Clay (B). *Draba reptans*, Jasper (B,D). *D. verna*, Jackson (B), Ripley (D). *Descurainea pinnata* v. *brachycarpa*, Delaware (BS). *Arabis hirsuta* v. *adpressipilis*, Pulaski (D,B). *A. laevigata*, De Kalb (D). *Berteroa incana*, De Kalb (D). *Polanisia graveolens*, Clay (B). *Grossularia missouriensis*, Fulton (D,B). *Heuchera americana* v. *brevipetala*, Clay (B).

Liquidambar styraciflua, Clay (B). *Hamamelis virginiana*, De Kalb (D). *Platanus occidentalis*, Clay (B). *Spiraea alba*, Clay (B). *Amelanchier arborea*, Clay (B), Franklin (B). *Rubus idaeus* v. *strigosus*, Lake (B,D). *R. occidentalis*, Clay (B). *R. pubescens*, Lake (D). *Fragaria virginiana* v. *illinoensis*, La Porte (D). *Potentilla monspeliensis*, Clay (B). **P. simplex** v. **calvescens** Fern. Rhodora 33: 189. Collected by C. C. Deam and R. C. Friesner. Cass (D), Fulton (D,B), Jasper B,D), Pulaski (D). *P. s.* v. *typica*, Clay (B), Pulaski (D). *Agrimonia pubescens*, Wayne (D). *Agrimonia rostellata*, Clay (B). *A. pubescens*, Delaware (BS). *Rosa setigera*, Delaware (BS). *Prunus lanata*, Knox (B). *P. virginiana* f. *deamii*, Lake (B).

Cassia marilandica, Clay (B). *Gleditsia triacanthos*, Clark (D). *Medicago lupulina*, Clay (B), Delaware (BS). *Melilotus alba*, Clay (B). *Amorpha fruticosa* var. *angustifolia*, Clark (D,B). *Desmodium dillenii*, Delaware (BS). *Lespedeza stipulacea*, Clay (B). *Amphicarpa bracteata* v. *comosa*, Clay (B), Delaware (BS). *Oxalis europaea* v. *bushii* f.

vestita, Delaware (B). *O. e.* f. *cymosa*, Clay (B), Delaware (BS). *O. e.* v. *villicaulis*, Delaware (BS). *O. repens*, Wells (D,B). *Evonymus obovatus*, Clay (B). *Staphylea trifolia*, Adams (D). *Acer negundo*, Steuben (D). *A. saccharinum*, Clark (D). *Impatiens biflora*, Delaware (BS). *Parthenocissus quinquefolia*, Delaware (B). *Hypericum gentianoides*, White (B). *H. punctatum*, Delaware (BS). *Viola arvensis*, (B,D). *V. cucullata*, Lake (D). *V. pedata* v. *linearíloba*, Harrison (B). *V. triloba*, Harrison (B).

Passiflora lutea v. *glabrifolia*, Clay (B). *Jussiaea decurrens*, Clark (D). *Epilobium coloratum*, Clay (B). *Circaea quadrisulcata* v. *canadensis*, Fulton (D). *Aralia hispida*, Pulaski (D). *Sanicula canadensis* v. *grandis*, Clay (B). *S. c.* v. *typica*, Clay (B), Delaware (BS). *S. gregaria*, Flanklin (B). *Chaerophyllum procumbens*, Clay (B). *C. tainturieri*, Knox (B). *Osmorhiza longistylis*, Clay (B), Delaware (BS). *Torilis japonicus*, Clay (B). *Conium maculatum*, Franklin (B). *Taenidia integerrima*, Lake (B,D). *Thaspium barbinode*, Clay (B), Franklin (B). *T. trifoliatum* v. *flavum*, Adams (D). *Angelica atropurpurea*, De Kalb (D). *A. venenosa*, Franklin (B). *Pastinaca sativa*, Clay (B). *Heracleum lanatum*, De Kalb (B,D). *Daucus carota*, Clay (B). *Cornus alternifolia*, Clay (B). *C. florida*, Jasper (BD). *C. obliqua*, Adams, (D), Pulaski (D). *C. racemosa*, Gibson (B). *Monotropa uniflora* Delaware (BS). *Fraxinus americana*, Allen (D). *F. pennsylvanica*, De Kalb (D). *F. tomentosa*, Adams (D,B). *Gentiana procera*, White (D).

Apocynum cannabinum, Clay (B). *A. c.* v. *glaberrimum*, Clay (B). *Asclepias phytolaccoides*, Clay (B). *A. tuberosa* ssp. *interior*, Bartholomew (B), Cass (B), Clay (B), Delaware (B), Elkhart (B), Floyd (B) Fulton (B), Knox (B), Lagrange (B), La Porte (B), Miami (B), Newton (B), Noble (B), Owen (B), Parke (B), Porter (B), Pulaski (B), Starke (B), Steuben (B), Tipton (B), Warren (B), Washington (B), White (B). *A. t.* ssp. *tuberosa* Bartholomew (B), Franklin (B), Harrison (B).

Ipomoea lacunosa, Decatur (B). *Phlox maculata*, Jasper (B). *P. pilosa*, Franklin (B). *Lappula echinata*, Putnam (B). *Hackelia virginiana*, Clay (B), Pulaski (D). *Myosotis scorpioides*, Lake (B). *M. verna*, De Kalb (B). *Mertensia verginica*, Harrison (B). *Lithospermum canescens*, Franklin (B). *Verbena hastata*, Clay (B). *V. simplex*, Hancock (B). *Teucrium canadense*, De Kalb (D). *Scutellaria parvula* v. *leonardi*, Lake (D,B). *Marrubium vulgare*, Franklin (B). *Agastache nepetoides*, De Kalb (D). *A. scrophulariaefolia*, Delaware (BS). *Prunella vulgaris* v. *lanceolata*, Delaware (BS). *Physostegia virgiana*, Franklin (B). *Lamium amplexicaule*, Jackson (B). *Leonurus cardiaca*, Adams (D), De Kalb (D), Delaware (BS). *Monarda fistulosa* v. *mollis*, Clay (B). *Blephilia hirsuta*, Clay (B). *Lycopus rubellus*, Adams (D), Delaware (BS). *Mentha arvensis*, Jennings (B).

Solanum carolinense, Pulaski (D). *S. dulcamara*, Pulaski (D). *S. nigrum*, Delaware (BS). *Verbascum thapsus*, Clay (B). *Chelone glabra*, v. *elatior*, Jennings (B). *C. obliqua* v. *speciosa*, Allen (D,B),

Lake (D). *Penstemon calycosus* Clay (B). *Veronica arvensis,* Clay (B), Delaware (BS). *V. peregrina* v. *typica,* Clay (B). *Castilleja coccinea,* Franklin (B). *Pedicularis canadensis* v. *dobsii.* Crawford (D). *Epifagus virginiana,* Adams (D), Clay (B). *Utricularia gibba,* Lawrence (D,B). *Phryma leptostachya,* Clay (B), Delaware (BS). *Plantago virginica,* Clay (B). *Galium aparine,* Clay (B). *G. ciraezans* v. *hypomalacum,* Clay (B). *G. concinnum,* Clay (B), Delaware (BS). *G. obtusum,* Clay (B). *G. triflorum,* Delaware (BS). *Viburnum lentago,* Delaware (BS). *V. molle,* Franklin (B). *V. prunifolium,* Clay (B). *V. rufidulum,* Franklin (B). *Triosteum aurantiacum,* Delaware (BS). *Cucurbita foetidissima,* Putnam (B). *Campanula americana,* Delaware (BS). *Specularia perfoliata,* Clay (B), Pulaski (B). *Lobelia siphilitica,* Delaware (BS). *L. spicata* v. *leptostachys,* Franklin (B).

Eupatorium fistulosum, Lagrange (D,B). *E. purpureum* Delaware (BS). *Kuhnia eupatorioides* v. *pyramidalis,,* Franklin (B). *Solidago gigantea* v. *leiophylla,* Clay (B). *S. patula,* Clay (B). *S. rgida,* Franklin (B). *S. rugosa,* Clay (B), White (D). *S. speciosa,* Franklin (B). *S. ulmifolia,* Franklin (B). *Aster cordifolius,* Clay (B), Delaware (BS). *A. laevis,* Franklin (B). *A. lateriflorus,* Delaware (BS). *A. macrophyllus,* v. *ianthus,* Franklin (B). *A. paniculatus* v. *simplex,* Daviess (B), Union (B). A. patens v. phlogifolius Nees, Gray Man. 7 ed. p. 807. Franklin (B,D). Collected by R. C. Friesner. *A. pilosus,* Wells (D). *A. puniceus,* Randolph (B). *A. sagittifolius,* Carroll (B), Union (B). *Erigeron annus,* Clay (B), *Delaware* (BS). *E. pulchellus,* De Kalb (D). *E. strigosus,* Clay (B), Delaware (BS), White (D).

Antennaria fallax v. *calophylla* Lake (B,D). *Silphium integrifolium,* Clay (B). *Silphium terebinthinaceum,* Franklin (B). **Iva xanthifolia** Nutt. Gray Man. 7 ed. p. 827. Lake (B). Collected by Floyd A. Swink and R. .C. Friesner. *Ambrosia coronopifolia,* Steuben (D,B). *A. elatior,* Clark (D), Clay (B), Delaware (BS), Jennings (B). *A. trifida,* Clark (D), Clay (B). *Helianthus decapetalus,* Clay (B), Delaware (BS). *H. hirsutus,* Delaware (BS). *Actinomeris alternifolia,* Clark (D). *Coreopsis tripteris,* Franklin (B). *Bidens frondosa,* Clay (B). *Galinsoga ciliata,* Allen (D,B). *Helenium autumnale,* Bartholomew (B). *Anthemis cotula,* Clay (B). *Achillea millefolium,* Clay (B). **Matricaria chamomilla** L. Gray Man. 7 ed. p. 847. Dubois (B). Collected by R. C. Friesner. *Chrysanthemum leucanthemum* v. *pinnatifidum,* Clay (B). *Artemisia annua,* Franklin (B). *A. biennis,* Putnam (B).

Carduus nutans, Allen (D). *Cirsium altissimum,* Franklin (B). *C. discolor,* Clay (B). *C. vulgare,* Delaware (BS). *Centaurea vochinensis,* Franklin (B). *Tragopogon dubius,* Clay (B), Franklin (B), Putnam (B). *T. pratensis,* Rush (B). *Lactuca biennis* f. *integrifolia,* Steuben (D). *L. canadensis* v. *latifolia,* Clay (B), Hamilton (B). *L. c.* v. *typica,* Hamilton (B). *L. floridana,* Delaware (BS). *L. saligna,* Jennings (B). *L. scariola,* Clay (B). *L. s.* v. *integrata,* Hamilton (B). *L. villosa,* Clay (B), Owen (B). *Prenanthes altissima,* Bartholomew (B).

Additional Species Added to the Deam Herbarium

The following species previously reported in other herbaria have been added to the Deam herbarium since the last report.

Osmunda cinnamomea, Pulaski. *Bromus tectorum*, De Kalb. *Poa chapmaniana*, Knox. *Phalaris arundinacea*, Porter. *Smilax herbacea* v. *lasioneura*, De Kalb. *Dioscorea villosa*, Fulton, *Populus grandidentata*, Huntington. *Polygonum pennsylvanicum* v. *geniunum*, Clark. *Fagopyrum esculentum*, Pulaski. *Silene antirrhina*, Jasper. *Lepidium campestre*, Jasper. *Potentilla monspeliensis*, Wayne. *Prunus lanata*, Harrison. *P. pumila*, Jasper. *Geranium carolinianum*, Jasper. *Acer rubrum*, De Kalb. *Lysimachia ciliata*, Randolph. *L. lanceolata*, Jasper. *Gentiana andrewsii*, Newton. *Asclepias syriaca*, Pulaski. *Ampelamus albidus*, Clark. *Linaria canadensis*, Lake. *Veronica peregrina* v. *xalapensis*, Gibson. *Ambrosia trifida*, Newton. *Xanthium pennsylvanicum*, Porter.

Nomenclatorial Changes

Cyperus pseudovegetus Steud. to
C. virens Michx.
Rhodora 47: 109-110. 1945.

Nelumbo pentapetala (Walt.) Fern. to
N. lutea (Willd.) Pers.
Phytologia 2:205-206. 1947.

Arabis pycnocarpa Hopkins to
A. hirsuta var. **pycnocarpa** (Hopkins) Rollins
Rhodora 43: 318-319. 1941.

Arabis pycnocarpa var. adpressipilis Hopkins to
A. hirsuta var. **adpressipilis** (Hopkins) Rollins
Rhodora 43: 319. 1941.

Amelanchier canadensis (L.) Medic. to
A. arborea (Michx. f.) Fern.
Rhodora 43: 563. 1941.
Illinois Biol. Monog. 20: 1-126. 1946.

Lathyrus japonicus var. glaber (Ser.) Fern. to
L. maritimus (L.) Bigel.
Phytologia 2: 209-212. 1947.

Parthenocissus inserta (Kerner) Fritsch to
P. vitacea (Knerr) Hitchc.
Phytologia 2: 204-205, 1947.

Rhus copallina var. latifolia DC to
R. copallina var. **latifolia** Engler
Indiana Acad. Sci. Proc. 55: 61. 1946.
Rhodora 37: 167-168. 1935.

Lycopus americana var. longii Benner to
L. americanus var. **scabrifolius** Fern.
Rhodora 47: 180-181. 1945.

State Flora Committee:
CHARLES C. DEAM, *Chairman.*
T. G. YUNCKER
RAY C. FRIESNER, *Secretary.*

CHEMISTRY

Chairman: ALVIN STRICKLER, Evansville College

Dr. E. St. Clair Gantz, Purdue University was elected chairman of the section for 1948.

ABSTRACTS

Basically substituted isoalloxazines. HOWARD BURKETT, DePauw University.—The structural resemblance of riboflavin to atebrin suggested the synthesis of basically-substituted isoalloxazines as possible antimalarials. The synthesis of three such compounds was described.

Experiments proving that oxygen rooms in hospitals should have entrances from above and not from the sides. FRANK C. MATHERS and H. GATOS, Indiana University.—Two carboys of thirty liters capacity were filled with oxygen and closed with rubber stoppers. One was inverted. The stoppers were removed for exactly the same number of minutes per day and later a 100 ml. sample was drawn from the center of each carboy for analysis. The per cent oxygen in the carboy with the opening at the top dropped from 87.0 to 50.2 in a total elapsed time of 23 hours, while that in the carboy with the opening at the bottom dropped from 86.2 to 49.0 in a total elapsed time of 34 minutes.

Changes in dehydro, reduced, and total ascorbic acid of cantaloupes on standing. KATHERINE J. ELLIOTT, SHIH DZUNG CHEN, and CECILIA SCHUCH, Purdue University.— Ten cantaloupes were analyzed for total and dehydro ascorbic acid immediately after cutting and after standing in the refrigerator and at room temperature for 24 hours. A measure of the reduced ascorbic present under each condition was obtained by difference. The losses in reduced ascorbic which occurred under both conditions of holding could be accounted for in part by conversion to the dehydro form.

The Reaction of Certain Nitro Alcohols with Aromatic Diazonium Bases and/or Salts*

Carl I. Gochenour with Ed. F. Degering, Purdue University

Historical Survey

In 1890 Demuth and Meyer (2) allowed 2-nitroethanol to react with benzenediazonium chloride and obtained an orange-red substance which melted at 104°C. A repetition of the work confirmed their result with the exception that the substance melted at 108°C. The freshly prepared product was colorless, but turned yellow on standing. The mechanism may be explained by the Bűlow reaction with hydrazones (1), the product being nitroformaldehydephenylhydrazone, $(NO_2)HC{=}N{-}NH{-}C_6H_5$.

The hydrazone formula for the product of coupling nitro- and similar reactive compounds with benzenediazonium chloride was suggested in 1888 by Victor Meyer (7).

In 1897 Pauwels (9) coupled the sodium salt of 2-nitro-1-pentanol with benzenediazonium chloride and obtained the hydrazone. The same product was obtained directly by the sodium salt of nitrobutane.

In 1895 Henry (4) treated the sodium salt of nitroisopropyl alcohol with benzenediazonium chloride and produced the phenylhydrazone, $Me.CH(OH).C(NO_2){=}N{-}NH.C_6H_5$. Also from 1-nitro-2-butanol, he obtained a phenylhydrazone, $Et.CH(OH).C(NO_2){=}N{-}NH.C_6H_5$. He also chlorinated 1-nitro-2-pentanol directly and obtained 1-chloro-1-nitro-2-pentanol. This was coupled with benzenediazonium chloride and yielded the phenylhydrazone as brilliant red needles, m.p. 92-94°C.

In 1896 Henry (5) coupled, 3,3,3-trichloro-1-nitro-2-pentanol with benzenediazonium chloride in an aqueous solution immediately after addition of sodium hydroxide. This yielded a phenylhydrazone, m.p. 129°C.

In 1901 Mousset (8) coupled the sodium salt of 1-nitro-2-hexanol with benzenediazonium chloride and obtained a phenylhydrazone with m.p. 108-111°C. The chloro-derivative was obtained as an oil.

In 1913 Rosenmund (10) coupled the sodium salt of 2-nitro-1-phenylethanol with benzenediazonium chloride and obtained the phenylhydrazone as fine red needles with m.p. 126°C.

In 1930 Jones and Kenner (6) prepared ω-nitroacetaldehydephenylhydrazone from 2-nitro-1-propanol and benzenediazonium chloride, (yellow plates, m.p. 149°C), according to the equations:

$$C_6H_5.N(:N)+Cl^- + CH_3.CHNO_2.CH_2OH \rightarrow$$
$$C_6H_5.N{=}N.CH(CH_3)(NO_2) + H.CHO + HCl, \text{ then}$$
$$C_6H_5.N{=}N.CH(CH_3)(NO_2) \rightleftarrows C_6H_5.NH.N{=}C(CH_3)(NO_2).$$

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* An abstract of a thesis submitted to the Faculty of Purdue University in partial fulfillment of the requirements of the degree of Master of Science, February, 1944, by Carl I. Gochenour.

They also observed that with an increase in the complexity of the groups X and Y, the stability of the compound $X.CH(OH).CHY.NO_2$ toward alkali diminishes, as in the case of the aldols. For instance, whereas the hydroxymethyl derivatives prepared from nitroethane, 1-nitropropane, and 1-nitrobutane are convertible into their sodium salts, analysis of those compounds prepared from the hydroxyethyl derivative undergo decomposition by alkali. Feasley and the senior author studied the condensation of aromatic diazonium compounds with the nitroalkanes in 1942.

Theoretical

A study was made of the reaction between aromatic diazonium salts and certain nitroalcohols, as 2-nitro-1-butanol, 3-nitro-2-pentanol, 3-nitro-2-butanol, and 2-nitro-1-pentanol. The diazonium chloride was prepared in the usual manner in an excess of acid. It was neutralized with a slight excess of base in the cold and coupled with the salt of a nitroalcohol. It was observed that 3-nitro-2-pentanol, 3-nitro-2-butanol, and 2-nitro-1-pentanol are decomposed by alkali in accordance with the equations:

$CH_3.CH(OH).CHEt.NO_2 + NaOH \longrightarrow CH_3.CHO + EtCH{:}NO_2Na$,
$CH_3.CH(OH).CHMe.NO_2 + NaOH \longrightarrow CH_3.CHO + MeCH{:}NO_2Na$, and
$HO.CH_2.CHPr.NO_2 + NaOH \longrightarrow HCHO + PrCH{:}NO_2Na$.

Under the same conditions, however, the desired sodium salt was obtained from 2-nitro-1-butanol:

$$HO.CH_2.CHEt.NO_2 + NaOH \longrightarrow HOCH_2.CEt{:}NO_2Na$$

These observations confirm the report of Jones and Kenner (6).

Those alcohols which decompose in alkali form a hydrazone when coupled with an aromatic diazonium salt. The reaction between 3-nitro-2-pentanol and benzenediazonium chloride may be shown by:

$$C_6H_5N(\vdots N) + Cl^- + CH_3CH(OH).CHEt.NO_2/OH^- \longrightarrow$$
$$CH_3.CHO + CH_3.CH_2.C(NO_2){:}N.NH.C_6H_5 + H_2O + Cl^-.$$

The reaction was confirmed by reacting benzenediazonium chloride with 1-nitropropane. The same product was obtained by treating benzenediazonium chloride with 1-nitropropane, as evidenced by the same color, same crystalline structure, and identical melting points.

The reaction between the sodium salt of 2-nitro-1-butanol and benzenediazonium chloride may be shown by:

$$HO.CH_2CHEt.NO_2Na + C_6H_5.N(\vdots N) + Cl^-/(OH) \longrightarrow$$
$$C_6H_5.N{=}N.C(NO_2)(Et)CH_2.OH.$$

If, however, this product is not removed immediately from the alkaline solution by precipitation with hydrochloric acid, it will lose formaldehyde and form the hydrazone. Pauwels (9) formed the hydrazone from this reaction after letting the product stand for several days. In our studies this product was immediately removed from the alkaline solution in order to obtain the azo linkage instead of hydrazone formation. The linkage was confirmed by analysis for nitrogen by the Dumas method.

Most of the products prepared were not stable even though they were recrystalized several times from 95 per cent ethanol. Although they did not decompose rapidly, over a period of several weeks, they gave a dark oil. The nature of the decomposed material was not investigated.

Another phase of this work was the determination of the pH of the solution in which the coupling takes place. An attempt was made to correlate the yield and alkalinity of the coupling solution. The amine used in this investigation was *p*-chloroaniline. The yield of product obtained was a direct function, within certain limits, of the alkalinity with the minimum pH being about 10.8.

Experimental

In preparing these compounds a solution of the aromatic amine (0.2 mole) in 60 ml. of concentrated hydrochloric acid (sp. gr. 1.19) and 125 ml. of water is diazotized by the dropwise addition of 15 g. of sodium nitrate in water. The diazotized solution is then neutralized by pouring it with stirring into a suspension of 500 g. of ice in 500 ml. of 2*N* sodium hydroxide (41.3 g. of sodium hydroxide in 500 ml. of water). Immediately after neutralization in an excess of sodium hydroxide, a previously prepared solution of 0.2 mole of the nitro alcohol in 8.0 g. of sodium hydroxide and 250 ml. of water is poured in with stirring. The solution is stirred until coupling is completed and is then filtered in the cold to remove traces of unreacted diazotized material. The filtrate is immediately acidified with concentrated hydrochloric acid (sp. gr. 1.19) and the product is filtered. The compounds are purified by recrystallization several times from 95 per cent ethanol.

The physical properties of the compounds that have been highly purified and proven by chemical analysis for nitrogen are given in Table I.

Correlation Between pH Values and Yields

In determining the pH of the coupling liquor at which maximum yields are obtained, a stick-antimony electrode (11) was used.

The coupling was conducted by using diazotized p-chloroaniline and the sodium salt of 2-nitro-1-butanol. The same procedure was used throughout this series of experiments. The only variation was the amount of base used for the coupling medium. The results that were obtained are given in Table II.

These data indicate that the alkalinity of the coupling solution is a major factor for coupling compounds of this type.

Summary

1. Most nitroalcohols decompose in an alkaline medium and form hydrazones upon coupling with aromatic diazonium salts.

2. 2-Nitro-1-butanol will couple with aromatic diazonium salts without decomposition.

3. The yield, obtained from an amine and nitroalcohol which couple without decomposition, is greater in an alkaline medium.

TABLE I. Compounds Prepared, Purified, and Analyzed

Compounds	Exp. No.	Mol. Wt.	% Calc.	N_2 found	Color	M.P. °C
1.	R.3	282	19.97	19.98	red	119-120
2.	R.11	301.9	13.9	14.0	orange	112.5-113.5
3.	R.12	257.46	16.31	16.64	orange	107.5-108
4.	R.15	257.46	16.31	16.75	red	78-79
5.	R.16	291.92	14.40	14.39	amber	93-94
6.	R.17	301.9	13.9	14.00	brown	84
7.	R.18	237	17.72	18.2	red	87-88
8.	S.3	252	22.22	22.23	red	117-118
9.	S.11	271.9	15.39	15.38	red	110-111
10.	S.12	227.46	18.46	17.98	red	106.5-107.5
11.	X.16	257.92	16.28	16.52	salmon	108-109
12.	Q.18	221	19.00	18.89	red	71-72

The twelve compounds referred to in the table are: (1) 2-nitro-2-(3-nitro-5-methylphenylazo)-1-butanol (2) 2-nitro-2-(4-bromophenylazo)-1-butanol (3) 2-nitro-2-(4-chlorophenylazo)-1-butanol (4) 2-nitro-2-(2-chlorophenylazo)-1-butanol (5) 2-nitro-2-(2,5-dichlorophenylazo)-1-butanol (6) 2-nitro-2-(2-bromophenylazo)-7-butanol (7) 2-nitro-2-(4-methylphenylazo)-1-butanol (8) 1-nitropropionaldehyde-(4-nitro-2-methylphenylhydrazone) (9) 1-nitropropionaldehyde-(4-bromophenylhydrazone) (10) 1-nitropropionaldehyde-(4-chlorophenylhydrazone) (11) 1-nitroacetaldehyde-(2, 5-dichlorophenyhydrazone) (12) 1-butyraldehyde-(4-methylphenylhydrazone).

TABLE II. Correlation Between pH and Yield

EMF	pH	% Yield	EMF	pH	% Yield
.6020	11.0	3.1	.7222	13.0	45.7
.6342	11.5	14.0	.7517	13.5	53.2
.6640	12.0	24.0	.7616	13.7	55.0
.6952	12.6	34.9	.7742	13.9	55.6

Bibliography

1. Bülow, Annalen, **236**:195 (1885).
2. Demuth and Meyer, Analen, **256**:30 (1890)
3. Feasley, C. F., and Degering, Ed. F., J. Org. Chem., **8**:12 (1942).
4. Henry, Bull. Acad. Roy. Belg. **15**:999 (1895).
5. Henry, Bull. Acad. Roy. Belg., **15**:1223 (1896).
6. Jones and Kenner, J. Chem. Soc. 1930, 919-28 (1930).
7. Meyer, V., Ber. **21**:11 (1888).
8. Mousset, Bull. Acad. Roy. Belg., **26**:622 (1901).
9. Pauwels, Bull. Acad. Sci. Belg., **34**:651 (1897).
10. Rosenmund, Ber. **46**:1037 (1913).
11. Robinson and Britton, J. Chem. Soc. 1931, 458-73 (1931).

Saccharic Acid Preparation by the Nitric Acid Oxidation of Glucose*

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Saccharic acid has long been known as a product of the oxidation of glucose, but its preparation has never become industrially important. At present it is priced far too high. It is believed that it could be manufactured and sold in competition with tartaric acid. Derivatives of these two acids have common properties. Tartaric acid is manufactured almost solely from wine lees (1), but because of recent shortages, interest has been aroused in its synthesis from other sources (2). Several patents exist for its direct manufacture by the nitric acid oxidation of starch, or indirectly from 5-ketogluconic acid (6).

In a search for other derivatives that could be prepared by the oxidation of glucose, interest centered on saccharic acid. It is commonly prepared by the method of Fischer as modified by Kiliani (3), but the method has been insufficiently studied for application to large scale production. In this work a study was made of the methods of improving the yields and simplifying the procedure.

One of the best known of the nitric acid oxidations of carbohydrates is that of galactosides to yield mucic acid. A study has been reported also of the oxidation of xylose (5), as a possible outlet for the utilization of waste pentosans. The most extensive study of the oxidation of glucose has been that of Kiliani (4).

Although the methods used in the preparation of saccharic acid are much the same as those used for the manufacture of mucic acid, they are complicated by the fact that the former is soluble in the oxidation mixture. As a result of extensive studies, Kiliani was able to obtain only a 25% yield (3). By the simple procedure described in this report it has been possible to obtain greater than 30% yields, and in some cases as high as 50%.

Proposed Procedure

The proposed method is the result of an extensive study of the conditions necessary for obtaining good yields of saccharic acid from the nitric acid oxidation of glucose.

Glucose, or starch, is dissolved in 20-50% nitric acid. If nitric acid of density 1.15 (about 25%) is used, this solution should be prepared in the ratio of 1 g. of glucose to 3.5 ml. of nitric acid. For the laboratory

* This paper is an abstract of portions of theses submitted by A. A. Dietz and J. W. Mench to the faculty of Purdue University in partial fulfillment of the requirements for the degrees of doctor of philosophy and master of science respectively in chemistry, June, 1941, and June, 1942. The work was sponsored by the American Maize-Products Company.

preparation of saccharic acid these concentrations of reagents have been found best, but certain adjustments would have to be made for larger scale production. A catalyst has not been found that will significantly increase the yield. If the above ratio of reagents is used, the solution should be heated until it has evaporated to ⅓ of the weight of the ingredients. The method used for the heating has not been found to be very important, but a slight advantage is found if the solutions are rapidly heated at first, and then allowed to continue to completion at 70-80°. The oxidation starts when the temperature reaches 75°, and then rapidly rises due to an exothermic reaction, until the temperature reaches 95°. At the onset of the oxidation NO_2 fumes are very strong and continue to be vigorously evolved for several minutes after the temperature reaches 95°. The vigorous oxidation then suddenly ceases and the temperature begins to drop, if the solution is not heated excessively. At this point practically no oxidation product can be isolated in the regular manner, but with continued heating at about 75°, the amount of recoverable saccharic acid goes through a maximum. This maximum is attained when the weight has been reduced to about ⅓ that of the original ingredients. If the oxidation mixture is cooled to 0° at the termination of the oxidation, about ½ of the oxalic acid will crystalize out, which will decrease the amount that will have to be removed by extraction.

The oxidation mixture is then extracted with ether until the extraction residue is almost devoid of nitric acid. At this point the oxalic acid will also be removed. The oxalic acid can be recovered from the ether extract by any convenient means, but care must be exerted to see that the extract is not evaporated to the point at which the oxalic acid will be vigorously oxidized. Solvents other than ether might be advantageously used, and in a large scale production the extraction could be carried out by pumping the solvent through the solutions to be extracted. This extraction must be carried out not far above room temperature, because of the dangers involved in vigorous oxidations at elevated temperatures.

The extraction residue is then made alkaline with potassium hydroxide, and sufficient time is allowed to saponify the lactone completely. This solution is then half acidified with a second batch of the extraction residue, and the potassium bisaccharate filtered off after it is completely precipitated. This filtrate is then made alkaline and the process repeated. Acetic acid can be used for the half acidification of the alkaline solution if sufficient is added to bring the pH to about 3.5. The potassium bissaccharate does not precipitate completely. It is only about 1.1% soluble in water, but is apparently more soluble in the presence of impurities. Additional product can be recovered from the potassium bisaccharate filtrate by the addition of calcium chloride. In many cases the salt has a CaO equivalent corresponding to that of calcium saccharate, and it is possible to convert a large portion of it to potassium bissaccharate. It is likely that if various fractions could be worked, products other than oxalic and saccharic acids could be recovered, but this has not been found feasible in small scale preparations.

Some results are recorded in Tables 1, 2, and 3 and presented graphically in Figures I, II, and III.

TABLE 1. Acid Catalysts with Nitric Acid

	Cat.	Ratio	Oxalic		KH-salts		N. E.
1.	H_2SO_4	1/3	1.40	2.9	10.65	33.0	256.0
2.	H_3PO_4	1/1	2.55	5.3	10.30	32.8	256.8
3.	$HClO_4$	1/20	0.55	1.2	12.20	38.8	253.7
4.	H_3BO_3	1/35	1.20	2.5	10.30	32.9	249.1

Column 2 is molar ratio of catalyst to glucose, 3 is g. of oxalic acid, 4 is % C returned as oxalic acid, 5 is g. of K bisaccharate, 6 is% C returned as K bisaccharate, and 7 is the neutral equivalent.

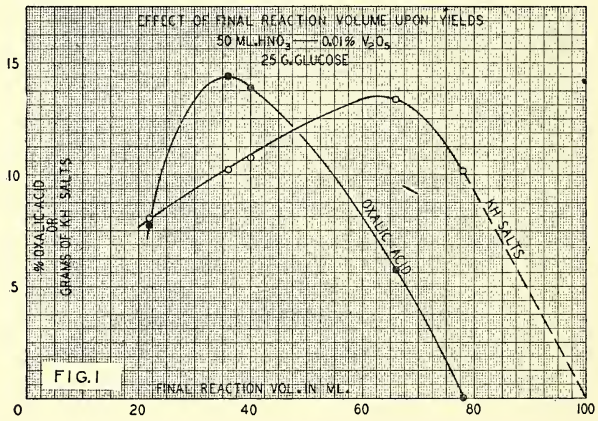


TABLE 2. Salt Catalyst with Nitric Acid

	Cat.	%	Oxalic		KH-salts		N. E.
1.	$AlCl_3$	1.0	0.20	0.4	11.85	37.0	246.9
		10.0	0.20	0.4	10.80	34.5	248.7
2.	$SnCl_2$	0.5	..	..	10.65	34.0	249.3
		10.0	..	..	3.15	10.2	250.4
3.	NH_4Cl	1.0	1.00	2.1	10.15	32.3	250.6
		10.0	0.55	1.2	9.15	29.2	251.3
4.	$ZnCl_2$	0.5	1.10	2.3	10.75	34.3	245.5
		10.0	..	..	12.30	37.7	257.7

Legend: See Table 1. Column 2 is % conc. of catalyst.

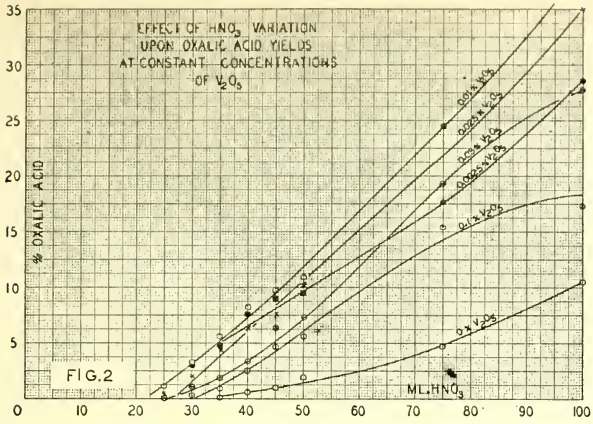
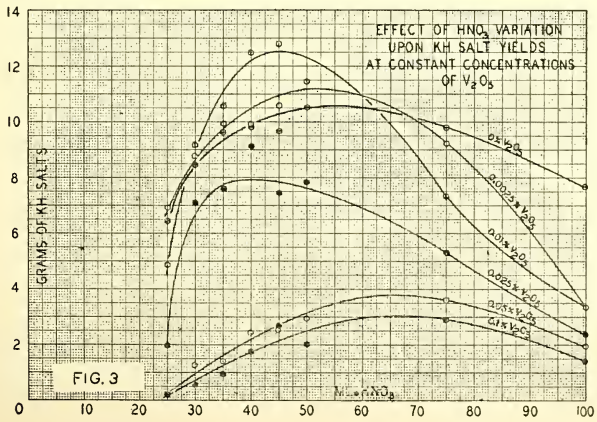


TABLE 3. Oxide Catalysts with Nitric Acid

	Cat.	1%	Oxalic		KH-salts		N.E.
1.	SiO_2	1.0	....	....	11.00	35.0	248.8
2.	CoO	0.6	3.30	7.4	10.60	33.8	323.0
3.	CuO	0.6	3.90	8.2	8.45	29.7	273.7
4.	Cr_2O_3	0.6	4.15	8.7	8.90	28.4	248.6
5.	Fe_2O_3	0.1	5.25	11.0	8.00	25.5	251.7
6.	NiO	0.2	4.30	9.0	9.25	29.4	298.2
7.	WO_3	0.2	4.70	9.8	7.50	24.0	261.8
8.	MoO_3	.05	6.95	14.0	9.75	31.0	276.8
9.	MnO_2	0.2	4.50	9.4	9.20	29.3	253.6
10.	V_2O_5	.05	13.9	29.0	1.95	5.5	187.7

Legend: See Table I. Column 2 is % conc. of catalyst.



Summary

Oxalic and nitric acids can be extracted from the oxidation mixture with ether, and the extraction residue can then be worked for potassium bisaccharate. The oxalic acid can be recovered.

Best yields of potassium bisaccharate are obtained if it is precipitated by half acidification of dipotassium saccharate. After the addition of acid, sufficient time must be allowed for the lactone to saponify.

It is believed that by the methods described in this portion of the thesis, saccharic acid derivatives can be manufactured in competition with corresponding derivatives of tartaric acid.

Bibliography

1. Black, J. W., *Ind. Chemist,* **14**:443-4, 483, 521-4. (1938); **15**:100-1. (1939).
2. Coghill, R. D., *Abstr. St. Louis Meeting,* Amer. Chem. Soc., Section K, 2 (April, 1941).
3. Kiliani, H., *Ber.* 58B, 2344-62. (1925).
4. Kiliani, H., *J. Chem. Education,* 8:1908-14. (1932).
5. Kline, G. M., and Acree, S. F., *Ind. Eng. Chem.,* **22**:975-80. (1930).
6. Pasternack, R., and Brown, E. V., (to Charles Pfizer and Co.), U. S. Patent 2,197,021 (April 16, 1940).

Derivatives of the Lower Aliphatic Amines

KENNETH N. CAMPBELL, BARBARA K. CAMPBELL and SR. ELEANOR MARIE SALM, University of Notre Dame

In previous work in this Laboratory, low molecular-weight amines have frequently been obtained as hydrolysis products of more complex compounds; thus when 2,2-diphenyl-3-methylethylenimine is heated with calcium oxide, and the product hydrolyzed with dilute acid, ethylamine is formed(1):

$$(C_6H_5)_2C\underset{NH}{\overset{\diagdown\ \diagup}{-}}CHCH_3 \xrightarrow{CaO} (C_6H_5)_2C{=}NHC_2H_5 \xrightarrow[H^+]{H_2O} C_2H_5NH_2 + (C_6H_5)_2C{=}O$$

In some cases, considerable difficulty has been experienced in identifying these amines, because they have been formed in dilute aqueous solution, from which it is difficult to isolate them, and because most of the common amine reagents give oily or low-melting solids with the low molecular weight amines, and these derivatives are not sufficiently characteristic for identification purposes. The object of the present work was, therefore, to seek a reagent which would give more suitable derivatives.

Such a reagent would have to have certain characteristics. It must not react with water, and it must be capable of reacting with amines in low concentrations (5-10%). The reaction must proceed in high yields, and the products must be essentially insoluble in water, and of fairly high melting point. While many reagents have been proposed for derivatizing amines, many of them have not been investigated with the lower aliphatic amines, and of those that have been so studied, none of them meets all the above requirements.

The aryl isocyanates are widely used to derivatize amines. They do react readily with most primary and secondary amines, and give good crystalline derivatives, but since they also react very rapidly with water, they are not satisfactory for our purpose:

$$ArNH\text{-}CO\text{-}NHAr \xleftarrow{H_2O} ArN{=}C{=}O \xrightarrow{RNH_2} ArNH\text{-}CO\text{-}NHR$$

The aryl acid azides proposed by Sah (2) are unsatisfactory for the same reason.

The aryl isothiocyanates, like their oxygen analogs, react well with most amines, and since they do not react readily with water, the presence of some moisture is not a disadvantage. Although the phenyl- and o-tolylisothiocyanates tend to give oily derivatives with the lower aliphatic amines, this difficulty can be overcome by the use of p-methoxyphenyl (3) or alpha-naphthyl-isothiocyanates.(4) We have found, however, that these reagents cannot be used with dilute aqueous

solutions of amines (5-10%) because they are insoluble in water, and the reaction is too slow to be useful.

$$ArN{=}C{=}S \xrightarrow{RHN_2} ArNH\text{-}CS\text{-}NHR$$

A reaction that has been of much value in derivatizing primary and secondary amines is the one with acid anhydrides or acid chlorides to form substituted amides:

$$RNH_2 + (CH_3CO)_2O \longrightarrow CH_3CO\text{-}NHR$$
$$RNH_2 + ArSO_2Cl \longrightarrow ArSO_2NHR$$

In many cases this reaction can be carried out by the Schotten-Baumann technique, in aqueous solution, in the presence of an inorganic base to take up the acid formed in the reaction. Most of the acid anhydrides and acid chlorides commonly used for this purpose have certain disadvantages when applied to the lower aliphatic amines. Acetic anhydride, benzoyl chloride, benzene- and p-toluenesulfonyl chlorides give oily derivatives with these amines. 2,4-Dinitrobenzenesulfonyl chloride has been used by Billman (5) with aliphatic amines; the derivatives have good melting points, and can be formed in concentrated aqueous solution (30%), but not very well in more dilute solutions (5-10%). p-Acetaminobenzenesulfonyl chloride has been found by Magini (6) to react readily with some of the lower aliphatic amines in aqueous solution, to give derivatives of good melting points; this reagent probably merits further study. Reichstein (7) has used 3,5-dinitrobenzoyl chloride to derivatize amines, but he gives no experimental details.

Other reagents have been proposed, but it appeared to us that the best reagent would probably be an aromatic acid chloride or an arylsulfonyl chloride with a nuclear substituent, such as nitro, to raise the melting point of the derivatives. Such a reagent could probably be used with the standard Schotten-Baumann technique. Accordingly, we have investigated the reaction of 3,5-dinitrobenzoyl chloride, *para*-nitro- and *meta*-nitro-benzenesulfonyl chlorides and beta- napthalenesulfonyl chloride with all the aliphatic primary and secondary amines up to amyl. The amines were used in 5% aqueous solution, and were shaken for ¾—1½ hours with the reagent, in the presence of enough potassium hydroxide to keep the reaction mixture basic to litmus.

The results obtained with 3,5-dinitrobenzoyl chloride were very disappointing. Even on prolonged shaking of the reactants, apparently but little derivative was formed, for recrystallization of the water-insoluble material from alcohol gave, in every case, a large amount of ethyl 3,5-dinitrobenzoate, formed by esterification of the unused reagent, and little or no amide.

The best results were obtained with *para*-nitrobenzenesulfonyl chloride. This reagent gave good yields of crystalline products with practically all the amines tried, and the melting points of the derivatives were sufficiently high, and sufficiently far apart to be characteristic of each amine.

When *meta*-nitrobenzenesulfonyl chloride was used, good yields of crystalline derivatives were obtained in most cases. The products tended to melt lower than those from the *para*- isomer, however, and the melting points were closer together, making these derivatives less suitable for characterization purposes. With beta-naphthalenesulfonyl chloride, the results were much poorer. The yields were very low, so that it was necessary to use relatively large quantities of amine and reagent to get enough derivative for purification. The melting points of the derivatives lay between those from *meta*- and *para*-nitrobenzenesulfonyl chloride, and in several cases, oils were formed. The derivatives from these acid chlorides are recorded in Table I.

It is of interest to note that we were unable to obtain a satisfactory derivative from di-isopropylamine and from di-sec-butylamine with any of the reagents used. In every case, the product was very high melting, and analyzed for the potassium salt of the sulfonic acid. Apparently, in these two molecules, the steric effect of the large, branched chain groups, is sufficient to make attack on the nitrogen atom difficult. In other reactions, also, these amines are relatively inert.

Experimental Part

Reagents: The 3,5-dinitrobenzoyl chloride and the three sulfonyl chlorides were obtained from the Eastman Kodak Company, and were used without purification. Most of the amines were also obtained from Eastman Kodak; a few were student preparations.

para-Nitrobenzenesulfonamides.—These were prepared as follows: A 5% solution of the amine (15 ml.) was added to one equivalent of the reagent, suspended in 5 ml. of a 10% potassium hydroxide solution. The reaction mixture was shaken mechanically for forty-five minutes, the basicity of the solution being checked from time to time. When secondary amines were used, the insoluble product was collected, washed with water and recrystallized twice from 95% alcohol. When primary amines were used, the basic reaction mixture was filtered, and the filtrate acidified with hydrochloric acid. The precipitate so obtained was collected, washed with water and recrystallized twice from 95% alcohol.

meta-Nitrobenzenesulfonamides.—These were prepared in the same way, except that the reaction time was increased to seventy-five minutes.

beta-Napthalenesulfonamides.—The same general procedure was used, except that 20 ml. of the amine solution and 10 ml. of 10% potassium hydroxide were used, and the mixture was shaken for one and one-half hours.

A representative number of the sulfonamides was analyzed for nitrogen; in every case the observed value was in good agreement with the theoretical value. (We wish to thank Mr. Charles Beazeley of the Microtech Laboratory, Skokie, Illinois, for carrying out these analyses.)

TABLE I.—Melting Points of Sulfonamides.

Amine Used	Arysulfonyl chloride Used		
	p-Nitrobenzene-	m-Nitrobenzene	beta-Napthalene
Methyl	110-111°C	117-118°C	105-106°C
Dimethyl	92-93	73-74	oil
Ethyl	105-106	77-78	81-82
Diethyl	134-135	65-66	83-84[a]
n-Propyl	84-85[b]	59-60	73-74
iso-Propyl	114-115	64-65	100-101
Di-n-propyl-	86-87[c]	59-60[d]	oil
Di-iso-propyl	340 with dec.[e]	320 with dec.[e]	oil
n-Butyl	81-82	55-56[f]	54-55
sec-Butyl	114-115	58-59	101-102
iso-Butyl	94-95	84-85	84-85
tert-Butyl	104-105	99-100	.....
Di-n-butyl	55-56	59-60[g]	66-67
Di-sec-butyl	320 dec.[e]	320 dec.[e]	no product
Di-iso-butyl	91-92[h]	87-88	81-82[i]

(a) Calculated N, 5.31%, found, 5.02%. (b) Calc'd N, 11.47%, found, 11.05%. (c) Calc'd N, 9.78%, found, 9.43%. (d) Calc'd N. 9.78%, found, 9.62%. (e) Calc'd for K salt of sulfonic acid, N, 5.8%, found, 5.41, 5.75, 5.35, 5.64. (f) Calc'd N, 10.84, found, 10.77%. (g) Calc'd N, 8.91, found, 8.53. (h) Calc'd N, 8.91, found, 8.78%. (i) Calc'd N, 4.38%, found, 4.10%.

Summary

Methods of derivatizing dilute aqueous solutions of the low molecular weight aliphatic amines have been investigated. The best results were obtained with *para*-nitrobenzenesulfonyl chloride; *meta*-nitrobenzenesulfonyl chloride was fairly satisfactory. The yields from beta-napthalenesulfonyl chloride were very low, and no satisfactory derivatives could be obtained under the conditions used with 3,5-dinitrobenzoyl chloride. Several new sulfonamides have been prepared and their melting points tabulated.

References

1. Campbell and Campbell, J. Org. Chem., **9**:178 (1944).
2. Sah, Rec. trav. chim., **58**:1008 (1939).
3. Campbell, Campbell and Patelski, Proc. Indiana Acad. Sci., **53**:119 (1944).
4. Shriner and Fuson, *The Systematic Identification of Organic Compounds,* 2nd ed., John Wiley and Sons, New York, p. 126 (1940).
5. Billman, J. Am. Chem. Soc., **63**:1920 (1941).
6. Magini, Att. accad. Italia Ren. classe sci. fis. nat., (7), **1**:452 (1940); Chem. Abst., **37**:98 (1943).
7. Reichstein, Helv. chim. Acta, **9**:799 (1926).

The Relative Stability of Some Copper (II) Complexes*

PEGGY MCINTIRE NELSON and E. ST. CLAIR GANTZ, Purdue University

The existence of complex ions and complex compounds has long been of interest to chemists. Copper (II) is a strong complex former and usually exists as a complex ion in solution. Very little study has been made of the stabilities of the copper (II) complexes.

In view of this, a spectrophotometric study was made of the relative stabilities of some of the copper (II) complexes using a Beckman spectrophotometer to measure the transmittancy of various anions. Since each copper (II) complex has a characteristic hue discernible by transmittancy curves, it was possible to compare curves of individual anions with those of mixtures of anions and establish relative stabilities of the complexes.

In 1892, H. M. Vernon (3) studied the color of copper (II) salts using the sulfate, chloride, nitrate, and acetate. He used a colorimeter which consisted of 2 graduated glass tubes with flat bottoms, about 2.5 cm. in diameter. Vernon found that the difference in color between the chloride, nitrate, and sulfate was very slight.

French and Lowry (1) studied the absorption spectra and coordination of various copper (II) compounds, both organic and inorganic. They ascertained that the different behavior of various metallic derivatives, especially their different behavior toward solvents, could be attributed to the varying stability of the coordinated complexes, rather than to the presence or absence of coordination.

In 1927, Job (2) studied complex formations and their stabilities. He mixed sodium bromide with 3.92 *M.* copper (II) nitrate and found that the bromide complex was more stable than the nitrate complex.

Experimental Work

A stock solution of 0.1 *M.* copper (II) chloride complex was prepared by dissolving C.P. $CuCl_2 2H_2O$ in 0.2 *M.* hydrochloric acid. The resulting solution was analyzed for copper by titration with a standard solution of sodium thiosulfate. Four tenths molar stock solutions were prepared of all anions to be studied. Throughout these studies, all solutions used were prepared on the assumption that copper has a coordination number of four.

Transmittancy measurements were made with a Beckman spectrophotometer using a slit width of less than 2 mm. A tungsten filament lamp served as the source of light. The transmittancy measurements were made in 1.000, $\pm$ 0.002, cm. absorption cells at every 20 millimicron interval in wave length.

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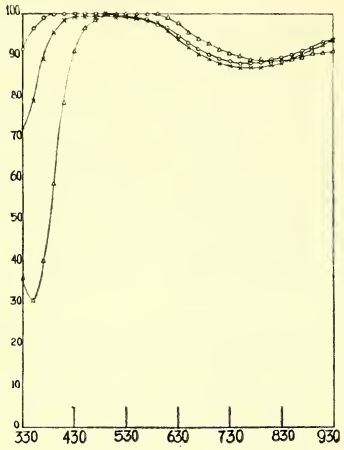
* This is an abstract from a portion of a thesis submitted to the Faculty of Purdue University by Peggy McIntire Nelson in partial fulfillment of the requirements for the degree of Master of Science, February, 1948.

The effect of each anion was measured in the presence of the chloride ion and the transmittancy curves compared to the curve for copper (II) chloride complex. These curves served as standards when



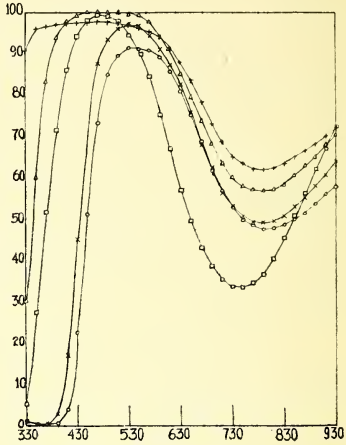
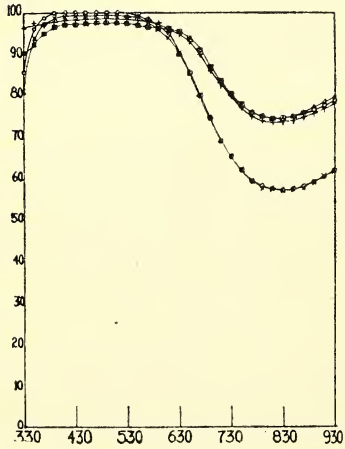


Fig. 1. Transmittancy curves for Copper (II) complexes of o) Oxalate ion (0.004 M); x) Oxalate and Thiocyanate ions; △)Thiocyanate ion (0.008M).

Fig. 2. Transmittancy curves for Copper (II) complexes of O) Thiocyanate ion (0.04M); x) Thiocyanate and Citrate ions; △) Citrate ion (0.013M); □) Citrate and Acetate ions; +) Acetate ion (0.04M).



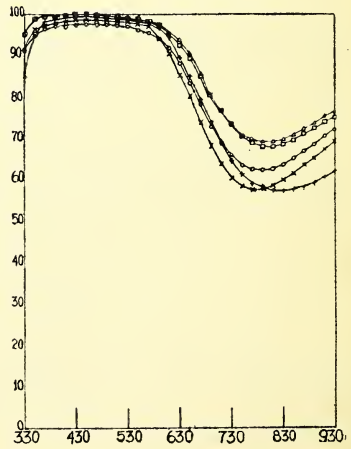


Fig. 3. Transmittancy curves for Copper (II) complexes of O) Acetate ion (0.04M); x) Acetate and Formate ions; △) Formate ion (0.04M); □) Formate and Tartrate ions; +) Tartrate ion (0.02 M).

Fig. 4. Transmittancy curves for Copper (II) complexes of O) Tartrate ion (0.02 M); x) Tartrate and Bromide ions; △) Bromide ion (0.04 M); □) Bromide and Phosphate ions; +) Phosphate ion (0.0133 M).

two anions were mixed to determine the stability of one with respect to the other. The chloride ion was selected as a standard because of its large instability constant.

Each anion was measured in the presence of every other anion and by comparing transmittancy curves the stability list was established. A solution of 0.01 *M.* in copper (II) chloride complex and 0.02 *M.* in sodium oxalate gave a voluminous precipitate. Consequently, it was necessary to use a solution of lower concentration which was 0.002 *M.* in copper (II) chloride complex and 0.004 *M.* in oxalate ion.

In figures 1, 2, 3, and 4, it is shown how the relative stability was established. In each figure the ordinate is the per cent transmittancy and the abscissa is the wave length in millimicrons.

The relative stability was established by comparing the transmittancy curve of a mixture of two anions being studied with the transmittancy curve of each anion. The curve of the anion that the mixture more nearly resembled was the curve of the more stable complex.

The use of a sodium, potassium, or ammonium salt for the addition of an anion has practically no effect upon the transmittancy values.

Figure 1 shows that the oxalate complex is more stable than the thiocyanate complex.

Figure 2 shows that the thiocyanate complex is more stable than the citrate complex and that the citrate complex is more stable than the acetate complex.

Figure 3 shows that the acetate complex is more stable than the formate complex which is more stable than the tartrate complex.

Figure 4 shows that the tartrate complex is more stable than the bromide complex and that the bromide complex is more stable than that with phosphate.

The transmittancy curves obtained for the phosphate and sulfate ions were very similar. The curve obtained for the mixture of the two anions was like both the phosphate and sulfate curves. Hence, they were placed together in the list of relative stability. The same situation existed in the case of the chloride and nitrate anions.

Results

The relative stability observed for the copper (II) complexes, the most stable being listed first, is as follows:

Oxalate	Tartrate
Thiocyanate	Bromide
Citrate	Phosphate, Sulfate
Acetate	Fluoride
Formate	Chloride, Nitrate

Literature Cited

1. French and Lowry, Proc. Roy. Soc. (London), **106A**:489-512. (1924).
2. Job, P., Ann. Chem., (10) **9**:113-203. (1928).
3. Vernon, H. M., Chem. News, **66**:104, 114, 141, 152. (1892)

ENTOMOLOGY

Chairman: A. M. VANCE, Purdue University

Dr. W. P. Allyn, Indiana State Teachers College was elected chairman of the section for 1948.

ABSTRACTS

The entomologist in pest control. LEE C. TRUMAN, Arab Pest Control Co., Indianapolis.—Several years ago Purdue University began conducting conferences which were designed purely as training sessions for men in the field of commercial pest control. The response of the industry has been entirely beyond expectations. These training conferences have since been started at several Universities and State Colleges over the country. The pest control industry and those who employ firms in the pest control industry are generally looking for individuals who can apply a technical knowledge of insects to the practical application of control measures. The well trained and versatile entomologist who chooses to go into commercial pest control work has before him an almost unlimited field for expansion.

Problems and observations of a Kansas pest control operator. H. R. SHUYLER, Purdue University.—The author discussed a number of difficult problems in pest control which were encountered during the past year in and near Wichita, Kansas. Problems of a difficult nature and those which arise infrequently require study, effort, and observation over and above that given the everyday job.

Entomology at Purdue University. J. J. DAVIS, Purdue University. —The status of entomology at Purdue University with special reference to the new four year curriculum for commercial pest control operators was explained. A brief report on the research activities of the Experiment Station and Extension Division was given.

The relation of particle size to the toxicity of DDT dusts. R. P. MULLETT, Purdue University.—Various particle sizes of DDT mixed with the same particle size of pyrophyllite, at a 2 per cent dilution, were tested against the adult Mexican bean beetle for a comparison of the toxicity of these various dusts. The best results were obtained when the particle size was 44-53 microns.

A new sticker for sprays and dusts. B. ELWOOD MONTGOMERY, Purdue University.—During the past summer tests of a sticker for sprays and dusts have been carried on in experimental plots at Lafayette and in the spray schedule of several growers in the state. This sticker has shown great power of holding the residue resulting from dusts applied when leaves are wet with dew or from sprays. No injury from the material has been noted, although injury to potatoes from

copper dust was increased slightly by the addition of the sticker. The sticker was compatible with all dusts and sprays tested. Entomological tests of the residue were very limited but a lead arsenate spray containing the sticker showed considerable toxicity to tomato hornworms even after considerable rainfall while the same spray without the sticker had very little toxicity.

Preliminary report on the relative attractiveness of different wave lengths of radiant energy to corn borer moths. H. O. DEAY and J. G. TAYLOR, Purdue University.—Five sources of radiant energy were tested in 1947 to determine their relative efficiency in attracting corn borer moths to traps. Four of these sources radiated their maximum energy at one of the following wave lengths: 2537 Angstrom units (germicidal lamp), 3654 (ultra violet), 4357 (blue), and 5250 (green). The other source was a mercury vapor lamp radiating principally at the mercury lines of 3131, 3654, 4047, 4358, 5461, and 5780 A. The percentages of first generation moths caught by each source of radiation were: green 2.9, blue 15.4, germicidal 15.4, mercury vapor 17.6, and ultra violet 48.5. Sixty-seven per cent of the total captures were females. A new type of light trap was designed and built.

Sulfa-drugs for the control of American Foulbrood. B. ELWOOD MONTGOMERY, Purdue University.—American Foulbrood is a bacterial disease of the brood of honeybees, for which no control has been known previously. Experiments have shown that small amounts of some of the sulfa drugs are effective in eliminating foulbrood infection from colonies. However, some of the sulfa compounds including sulfathiazole which is the form most readily available to beekeepers, are quite toxic if fed in too large amounts. Present recommendations are for the use of sulfa-drugs for preventive measures only. Three feedings containing one-half gram each of sulfathiazole should be given at ten day intervals during the spring brood rearing season.

Insects of Indiana for 1947

J. J. Davis, Purdue University Agricultural Experiment Station

Abnormal weather prevailed during 1947, as shown by the accompanying table of weather conditions, which was favorable for some insects, but on the whole unfavorable to some of our more major pests. April, May, and June were abnormally wet, while the remainder of the season was nearly normal. May, June, and July were abnormally cool, with above normal temperatures prevailing thereafter. The early wet and cool weather interferred with crop planting and this had a definite bearing on insect infestations.

Field Crop Insects

Grasshoppers (*Melanoplus differentialis* Thos. and *M. femur rubrum* DeG.) were more abundant the past season than for many years and there is evidence that they may be even more abundant in 1948. They occurred throughout the state. Infestations developed in clover and alfalfa fields and in weedy areas. Because of the high temperatures during August, the weedy areas became unattractive to the developing hoppers, and this, with the cutting of alfalfa and clover, drove immature hoppers to greener vegetation, including corn, soybeans, vegetables and flower gardens, and orchards and nurseries. Poison bran bait, the usual recommendation, was ineffective because with the hot weather in August the grasshoppers stayed high on the plants. Tests with several of the new organic chemicals, including chlordane and benzene hexachloride, proved highly efficient. Two other new chemicals "Toxaphene" and parathion were also very effective controls.

The European corn borer (*Pyrausta nubilalis* Hbn.) shows the lowest population in several years. The past four years have been definitely unfavorable to the corn borer. A major control operation has been the delaying of corn planting until after May 20. Weather conditions have been such that little corn could be planted before that date for several years. Thus, weather conditions have automatically taken care of the date of planting, unfavorable to the corn borer. At the same time it should be remembered that the corn borer can build up rapidly with favorable conditions and if conditions another year are favorable for early planting of corn and if growers do not heed delayed planting recommendations, the borer may immediately become a serious problem.

Chinch bugs (*Blissus leucopterus* Say) show a very low population and there is little likelihood they will cause any trouble in 1948.

The Hessian fly (*Phytophaga destructor* Say), one of the major field crop pests, is not abundant and is unlikely to be a pest problem during the coming season. Adoption of the practice of sowing wheat after the "fly-free" date is recommended as a regular practice and its

TABLE I. Comparative Monthly Weather Data for Indiana, 1947

Month		Temperature		Precipitation		Number of Days		
		State Mean °F	Departure from Normal °F	State Average Inches	Departure from Normal Inches	Clear	Partly Cloudy	Cloudy
1946 November	Normal	42.5		3.06		11	7	12
	1946	46.8	+4.3	3.74	+0.68	11	6	13
December	Normal	32.2		2.72		9	7	15
	1946	36.8	+4.6	2.87	+0.15	10	7	14
1947 January	Normal	29.1		2.97		9	7	15
	1947	33.8	+4.7	3.80	+0.83	6	8	17
February	Normal	30.6		2.41		9	7	12
	1947	24.2	—6.4	0.34	—2.07	10	8	10
March	Normal	40.9		3.74		10	8	12
	1947	33.8	—7.1	2.17	—1.57	10	10	11
April	Normal	51.9		3.63		11	9	10
	1947	52.0	+0.1	7.03	+3.40	8	8	14
May	Normal	62.2		4.11		12	10	9
	1947	59.0	—3.2	5.17	+1.06	10	12	9
June	Normal	71.6		3.93		13	11	6
	1947	69.0	—2.6	5.21	+1.28	11	10	9
July	Normal	75.6		3.31		16	10	5
	1947	71.2	—4.4	3.12	—0.19	14	12	5
August	Normal	73.7		3.34		15	10	6
	1947	79.8	+6.1	3.44	+0.10	17	10	4
September	Normal	67.2		3.30		15	8	7
	1947	67.6	+0.4	3.98	+0.68	17	8	5

adoption is doubtless responsible for the low Hessian fly population over a period of years.

Corn flea beetle (*Chaetocnema pulicaria* Melsh.) was destructively abundant in several central Indiana localities.

Sweet clover weevil (*Sitona cylindricollis* Fahr.) is a pest of recent occurrence in Indiana, having been found only a few years ago, first in northern Indiana. This insect has been working southward rather rapidly and already has caused notable losses. Apparently it is already in the southern third of the state from reports of typical injury received although actual specimens have not been seen. The weevil is especially destructive to new plantings and is becoming increasingly important because more and more farmers are recognizing sweet clover

as a valuable soil improvement crop. Plans are under way to make an intensive study of this pest next year.

Army worms (*Cirphus unipuncta* Haw.) were noticeably abundant in a few scattered localities throughout the state, especially in northern Indiana.

The Fall Army worm (*Laphygma frugiperda* S. & A.) was destructively abundant in several localities in both northern and southern Indiana.

The alfalfa or garden webworm (*Loxostege similalis* Gn.) was responsible for the destruction of many newly planted alfalfa fields. Most of the inquiries came from the southern half of the state and the damage was noticeable from the last of August into September.

The common stalk borer (*Papaipema nebris* Gn.) was a common pest in many localities during the period from the last half of May into July. Many crops were attacked, the more common ones including corn, pepper, tomato and miscellaneous vegetable and flower garden plants.

The spittle bug (*Philaenus lineatus* L.) was again very common over the northern two thirds of the state, attacking almost every kind of plant, as in 1946.

Corn rootworm adults (*Diabrotica longicornis* Say) were unusually abundant in the southwestern part of the state, especially Posey County, along the Wabash and Ohio rivers. They cut off the silks of corn, thus preventing fertilization of the grains.

Vegetable Insects

The potato leafhopper *Empoasca fabae* Harr. was common and destructive to potatoes and beans throughout the state.

Blister beetles (especially *Epicauta pennsylvanica* DeG. and *E. vittata* Fab.) were common throughout the state, attacking all kinds of garden crops.

Scavenger beetles (*Ips quadriguttatus* Fab.) have been common for the past four or five years, and especially in the burrows of the corn ear worm and the European corn borer. They are also common on such fruits as strawberries and melons where decay starts, especially when the fruits are in contact with the soil.

Orchard Insects

Codling moth (*Carpocapsa pomonella* L.) was not as serious as usual. Furthermore the insecticide DDT has proven to be an unusually effective control and was rather generally used by fruit growers, especially those in the southern half of the state.

Oriental fruit moth (*Laspeyresia molesta* Busck) infestations were spotty and injury was less than usual.

Apple maggot (*Rhagoletis pomonella* Walsh) was less abundant than for several years, only a few reports of noticeable infestations being reported.

The plum curculio (*Conotrachelus nenuphar* Herbst) shows a very definite increase and for the first time in many years it is a real threat to the fruit industry of the state.

Shade Tree and Shrub Insects

Cottony maple scale (*Pulvinaria vitis* L.) has been the subject of many inquiries from the northern third of the state. This scale has been on the increase for the past two or three years and it is believed that further increase may be anticipated for 1948.

Bagworms (*Thyridopteryx ephemeraeformis* Haw.) was unusually abundant and was destructive as far north as Kokomo and Peru. The fact that this insect feeds on evergreens, especially arbor vitae, but also pines and junipers, makes it an especially serious pest. The bagworm is easily controlled with arsenate of lead if treatment is applied before the larvae are half grown. Unfortunately, in spite of publicity, the infestation is not usually recognized until it has partly or completely defoliated the evergreens.

The spring canker worm (*Paleacrita vernata* Peck) is on the decline, although a few reports of defoliation were received as far south as Scottsburg.

The bronze birch borer (*Agrilus anxius* Gory) has been more destructive than usual. Observations show that specimen trees are more often attacked but that where such trees are kept adequately watered and fertilized, the bronze birch borer does not become destructive.

Willow aphids (*Melanoxantherium smithiae* Monl.) were reported from many localities. Reports did not refer to damage to willow but where infested trees were near buildings or outdoor furniture, the blood red stain produced when crushed were very objectionable.

The locust leaf miner (*Chalepus dorsalis* Thumb) was noticeably abundant through central and southern Indiana.

The twig girdler (*Onicideras cingulata* Say) was frequently reported attacking persimmon, hickory and oak, especially in the south-western part of the state.

Household Insects

Cockroaches are still the major household pests and many inquiries are received each year. Although the German roach (*Blattella germanica*) is the species most often reported, the American roach (*Periplaneta americana*) and the Oriental roach (*Blatta orientalis*) are also very common.

Powder post beetles (*Lyctus* spp.) are an increasingly important problem and an unusually large number of inquiries are being received. Perhaps this may be attributed, in part, to the large amount of poorly seasoned lumber being used in building construction.

Psocids or book lice (Corrodentia) are the subject of many inquiries and here again this increase may be attributed to the use of unseasoned lumber.

Ants of various species continue to be major pests, in the lawn, as annoying pests in the home, and destructive to construction timbers. Many species of ants swarm in the fall of the year which leads the public to suspect termites. It should be noted that termites very rarely swarm after June in Indiana.

The cluster fly (*Pollenia rudis*) has been an annoying problem for housewives in the fall and spring. This fly is a parasite of earth-worms and passes the winter in the adult stage. It gains entrance to homes and there seeks cool places, such as the attic, unheated basement areas and in window casings. In the spring it becomes active and as in the fall, may be quite annoying, although it does no damage.

It is noteworthy that house flies (*Musca domestica*) have been rather scarce the past two years. I think this can be attributed more to the weather than to the use of DDT.

Termites (*Reticulitermes flavipes*) continue as a major building pest in Indiana.

Miscellaneous Pests

Annoying mites. During the course of a year frequent reports are received of mites invading buildings. In some cases they are plant mites occurring on vines; in other cases the tropical rat mite (*Liponyssus bacoti* Hirst) is the annoying species; but quite frequently the common poultry mite (*Dermanyssus gallinae* DeG.), which infests birds, especially the mourning dove, which nests on window ledges or in vines, eaves, etc.

Mites (*Tarsonemus confusus* Ewing, E. W. Baker det.) were the cause of trouble in a major tomato canning plant near Indianapolis. During the latter half of September, weather conditions caused the fruit stems of tomatoes to brown and show decay or a moldy condition. This was responsible, apparently, for a notable abundance of the above mite, especially just below the calyx lobes and this resulted in mite fragments contaminating the tomato pulp. In other words the presence of the mites had no harmful effect on the plants or fruits, but did present a serious hazard by contaminating the product with mite fragments, which might be considered adulteration by the U. S. Food and Drug Administration, thus subjecting the product to confiscation.

Bran beetles (cadelle, *Tenebroides mauritanicus* L.; confused flour beetle, *Tribolium confusum* Duval; and saw-toothed grain beetle, *Orzaephilus surinamensis* L.) have been serious pests in stored grains during the past year.

Tests for the Control of Corn Flea Beetles

Mark Curtis Wilson, Purdue University Agricultural Experiment Station

Description and Importance

During July 1947 a heavy infestation of the corn flea beetle (*Chaetocnema pulicaria* Melsh.) occurred on sweet corn seedlings near Franklin, Indiana. This insect is one of the common species of small black, stout-bodied flea beetles attacking corn, alfalfa and garden crops in the spring and early summer. About 1/16 inch long *C. pulicaria* is distinguished from similar species by not having pits on the head. The basal three segments of the antennae are reddish-yellow, the legs are brownish-yellow, and there are rows of pits on the elytra.

When abundant the corn flea beetle causes severe injury to young corn seedlings. The beetles swarm onto the young plants. The green portion of the leaf is eaten, giving the whole plant a bleached appearance. Growth is retarded, the leaves wilt and an entire crop may be devastated. However, once vigorous growth sets in the corn plant is able to sustain the beetle with little danger of the insect causing severe injury through feeding.

Of tantamount importance, *C. pulicaria* is also the vector of Stewart's disease in corn. Since *Phytomonas stewarti*, the causal organism of this disease, can overwinter only in the body of the insect, control of the beetle is a stark requisite where the disease is prevalent.

Dusting for Control

Tests for the control of the corn flea beetle were initiated in a heavily infested corn field where the beetles had laid waste to nearly fifty percent of the crop. Two experiments involving different materials were conducted. Various dust concentrations of DDT, DDD (dichloro-diphenyl-dichloroethane), benzene hexachloride, chlordane, Toxaphene (chlorinated camphene), Methoxychlor (methoxy analog of DDT), parathion (O,O-diethyl O-p-nitrophenyl thiophosphate, an experimental compound supplied by American Cyanamid Company), and cryolite were applied.

Sweet corn seedlings having two to five inches of growth received one application of dust applied with a hand knapsack duster. Each treatment was replicated six times. Plots were three rows wide and twelve feet long. Forty-eight hours after treatment data were taken by counting the surviving beetles on ten consecutive plants in the middle row of each plot.

These data show all materials to be superior to cryolite or parathion. Serious foliage burning resulted where cryolite was used. None of the other materials caused any injury. Highest control was obtained from benzene hexachloride and chlordane.

Data: Experiment I (Treated July 17)

Treatment	Average Beetle Survival per Plot	% Control
Control	26	0
Benzene hexachloride: 1% gamma isomer	0.3	98.8
Toxaphene: 2.5%	3.1	88.0
DDT (dichloro-diphenyl-trichloroethane): 2:5%	4.1	84.2
DDT (dichloro-dipheny-trichloroethane): 5.0%	4.3	83.4
DDD (dichloro-diphenyl-dichloroethane): 5.0%	7.3	71.9
Cryolite: 33.3%	8.8	66.1

Data: Experiment II (Treated July 22)

Treatment	Average Beetle Survival per Plot	% Control
Control	26.	0
Chlordane (Dowklor): 2.5%	3.0	88.4
Benzene hexachloride: 0.25% gamma isomer	4.3	83.4
Benzene hexachloride: 0.5% gamma isomer	6.9	73.4
Methoxychlor: 2.5%	5.5	78.8
Toxaphene: 2.5%	7.0	73.0
DDT: 2.5%	8.0	69.2
DDT: 1.25%	11.5	55.7
DDD: 2.5%	9.3	64.2
Cryolite: 40%	11	57.6
Cryolite: 33.3%	14	46.1
parathion: 1%	19.5	28.8

From these data it may be concluded that a 1% gamma isomer of benzene hexachloride dust and a 2.5% chlordane dust effect higher control of the corn flea beetle than a 5% DDT dust.

The Distribution and Relative Seasonal Abundance of the Indiana Species of Lestidae (Odonata: Zygoptera)

B. Elwood Montgomery, Purdue University

This is the fifth and final paper of a series indicating the relative seasonal abundance of the adults of the Indiana species of Odonata. The preceding papers (Montgomery 1942-1947) have included all of the species known from Indiana except those of the Lestidae which are the subject of the present discussion. These studies of relative abundance are based upon the frequency of collection and observation of the several species during the 41-year period of 1900 to 1940 inclusive.

Tabulations were made from records preserved in the collecting notebooks of the late E. B. Williamson and of the author. The chart (Fig. 1) accompanying this paper consists of a time-frequency graph for each of the ten species of the Lestidae from Indiana. The graphs were constructed by tabulating the records for the entire 41 years by thirds of months and plotting the resulting frequencies at the midpoints (5th, 15th and 25th respectively) of these thirds.

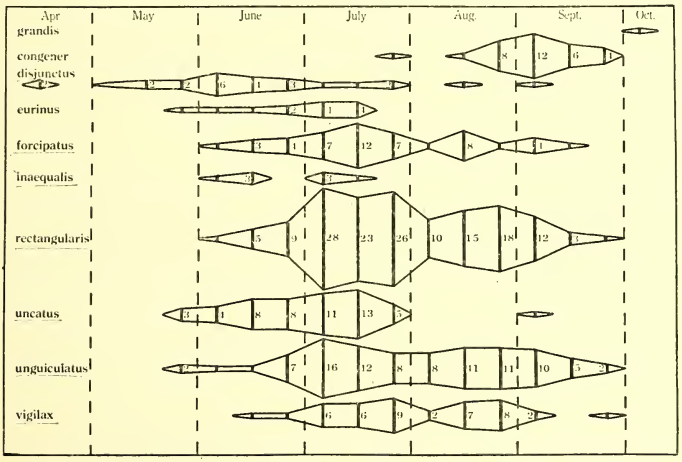


Fig. 1. The range of the flight season (or period of adult life) and the relative seasonal abundance of the species of the Lestidae (genera Archilestes and Lestes) in Indiana. Numbers near each bar indicate the number of collections of each species in each third of a month during the period of 1900 to 1940 inclusive; where no number is given the number of collections is one.

List of species with notes on distribution and an indication of the number of years each species was collected from 1900 to 1940 inclusive

Archilestes grandis (Rambur)—1. Northern South America through Central America, Mexico, Utah and Texas to Pennsylvania.

Lester congener Hagen—17. Throughout southern Canada and the United States except the southeastern and Gulf states.

L. disjunctus Selys—16. California and Alaska to the Carolinas and the Maritime Provinces.

L. eurinus Say—10. Northeastern-Iowa to New England and eastern Canada.

L. forcipatus Rambur—25. Oklahoma and Saskatchewan to Florida, Maine and Quebec. Although *forcipatus* and *disjunctus* have been confused in the past and many of the published records for *forcipatus* should be transferred to *disjunctus*, it seems probable that the recorded general distribution of the two species is approximately correct.

L. inaequalis Walsh.—6. Oklahoma and North Carolina to New England and Quebec.

L. rectangularis Say—35. Oklahoma and Minnesota to Georgia and the Maritime Provinces.

L. uncatus Kirby—23. Transcontinental—California and British Columbia to Maryland, the Maritime Provinces and Quebec. Cowley has indicated that *uncatus* is identical with the European *dryas* Kirby and has selected the latter name for the species.

L. unguiculatus Hagen—23. Distribution almost identical with that of the preceding species.

L. vigilax Hagen—19. Iowa to Florida and Quebec.

Of the ten species of Lestidae known from Indiana, *L. rectangularis* is the most common. This species was recorded for 35 of the 41 years covered by the records upon which these studies are based, and the frequency of records for it, especially during July and August, indicates that it is one of the more common species of the entire order in the state. *Archilestes grandis* has been reported for the state but once, near Liberty, in October, 1940, when a single specimen was taken along a creek bed (Montgomery 1941). A colony of this species seems to be well established at Oxford, Ohio, only about 12 miles away from the Indiana station. However, the local character of the known distribution of this species in Ohio, Kentucky and Missouri supports the the view that the relative abundance shown in the chart for this species is likely correct, even if *grandis* is permanently established in the state. *Lestes inaequalis* and *L. eurinus*, taken in six and ten years respectively from 1900 to 1940, may be ranked as comparatively rare species within the state. The other six species are all moderately abundant, at least seasonally, although the season for *congener* is short. The indicated abundance for *disjunctus* is probably too low and that for *forcipatus* too high. These species have been confused in the past (Montgomery 1941) and it was necessary to re-examine specimens to properly tabulate the records. Many specimens reported as *forcipatus* were found, upon restudy, to be *disjunctus*, but not all of the specimens recorded in the notebooks could be located for re-examination. Also,

the only large and permanent colony of *forcipatus* in the state known to the author is at the Vanemon Swamp. This swamp was the object of continued study and frequent visits by Mr. Williamson throughout the years of his work with Indiana Odonata.

In some of the groups considered in the earlier studies of this series (Agrionidae, Cordulidae and Libellulidae) traces of correlation between the seasonal range, or abundance, of the species in Indiana and their geographical range, or their evolutionary level, were noted. No evidence of such correlation can be found in the species of the Lestidae. The Lestidae have become adapted to conditions not generally favorable to Odonate life, although this adaptation does not exclude them from more favorable conditions and localities. In most species the winter is passed in the egg stage, concealed and protected in plant tissue. The eggs hatch at the beginning of the warm season and the nymphs develop with astonishing rapidity, becoming fully mature within a few weeks. Because of this mode of life, the species of Lestidae are frequently very abundant in localities where other Odonata are very scarce. Most of the Indiana Lestidae are lake or pond species; some are very abundant late in the summer around pools left in dried-up stream beds. Certain species frequently occur in great numbers around dried-up ponds in the late summer where no other dragonflies are found. Their development appears to be rather well correlated with conditions for life in such waters as they reach the adult stage just before the ponds or pools become dry.

Literature Cited

Montgomery, B. Elwood. 1941. Records of Indiana Dragonflies, X. 1937-1940. Proc. Ind. Acad. Sci., **50**:229-241.

———— 1942-1947. [The distribution and relative seasonal abundance of the Indiana species of Odonata.] Proc. Ind. Acad. Sci., **51**:273-278 (Enallagma); **53**:179-185 (Agrionidae); **54**:217-224 (Cordulidae and Libellulidae); **56**:163-169 (Calopterygidae, Pelaturidae, Cordulegasteridae, Gomphidae and Aeshnidae).

The Control of the Major Insect Pests and Diseases of Peaches

G. Edw. Marshall, Purdue University Agricultural Experiment Station

Continually recurring annual losses which should have been profits have been the lot of the Southern Indiana peach grower as the result of a complex arising from two insects whose attack has been severe for years. Attempts at the control of one or both of these pests have resulted in injury to the foliage and in turn impairment of fruit quality. Certain phases of this problem are not at all well understood. In fact, not until this fall does the way seem clear in the matter of the certainty of being able to grow choice crops of peaches every year.

Of the diseases and insect pests the grower has to consider, it is well known that peach leaf curl and San Jose scale may both be controlled by one and the same dormant spray application.

The tarnished plant bug, stink bug and possibly a few other sucking insect species attack the crop from about the time the blossoms fall in the spring until the fruit is half grown. Often much damage is done by these "bugs". The misshapen peaches resulting from attacks from these insects are spoken of as "cat-faced". Heretofore there has been little or nothing which could be done to prevent this injury except to cultivate the soil to destroy the sod and fence row growth where the attacking insects find cover. Clean cultivation as recommended would, in thousands of rolling or hilly orchards be extremely hazardous from the standpoint of soil erosion.

In tests this year we have found that the product known as Chlordane will completely control the insects causing cat-facing. This material injures plants little or none and though peach trees were not sprayed with it, sod areas around the orchard were sprayed and it was found to kill remarkably well for a period of two weeks or longer.

More serious, however, than cat-facing are the losses caused by the plum curculio. Through consistent and correctly timed sprays of acid lead arsenate this insect may be satisfactorily controlled, though the soluble arsenic in the spray often ruins the peach foliage. Lime has long been used to prevent arsenic injury but in general as used it has not been satisfactory. This is probably because not enough was used and certainly in many instances the lime was so old it was no longer hydrate but rather calcium carbonate. In the past an application of nitrate to the trees has been recommended when severe foliage injury makes its appearance but if the weather is dry when

the injury occurs and if it remains dry for a few weeks or longer the nitrate is not made available to the trees.

In 1946 and 1947 three sprays of acid lead arsenate were used to control the curculio. With each spray 16 pounds of freshly hydrated lime per 100 gallons of water were included and a week after the second and third lead arsenate spray a special spray of 16 pounds of lime alone in 100 gallons of water was used. Such lime applications may be withheld until foliage injury makes its appearance. In two of the lead arsenate sprays zinc sulphate was added to aid in the control of *Bacterium pruni.* All of these applications, and indeed, all applied during the season were made by using a Bean gun with a pressure of 550 pounds per square inch. Thus five sprays were used against the curculio, against the incident foliage injury accompanying the sprays and to control *Bacterium pruni.* In addition to this the dropped peaches were picked up and destroyed periodically. The foliage on this block of trees remained dense, dark green and beautiful throughout the season.

The orchard is a sod culture one and this makes conditions more favorable for the winter carry-over of the curculio and for the Oriental fruit moth. The latter insect has hitherto been uncontrollable with sprays where the infestation became heavy. This year, however, and for the first time, the insect was controlled by five applications of DDT (12 ounces actual DDT per 100 gallons of water; the material was put up as a 50 percent wettable powder). These sprays were applied five days apart beginning about 25 to 27 days before harvest. The first application included an inside-out spray and an outside-in one with the latter from the tower. The last four were from the outside-in only and the spray tower was used. The pressure as before was 550 pounds per square inch. No foliage injury of any kind could be detected as the result of this pressure.

Thus all the insects and diseases which take a heavy toll of the crop in most Southern Indiana orchards have been discussed with the exception of brown rot. Under this program in 1947 brown rot was of no consequence and not a single operation of any kind, other than the picking up of the dropped peaches, was applied against it.

The crop of peaches produced during this study was of the Gage Elberta variety. They were harvested between September 7 and October 1 and they packed 96 per bushel. The figures below show the state of the insect and disease attack at harvest as compared to a neighboring crop of midseason Elberta. This commercial orchard is less than a mile from the one where these studies were made. The midseason Elberta variety had at least the average number of sprays or dusts for curculio control and for the Oriental fruit moth and considerably more than the average number for brown rot which disease caused severe losses notwithstanding. The difference is striking, indeed, and to be able to produce crops of fine quality as simply as done through these studies will be a step toward the advancement of the fruit industry.

Variety	Insect-free	Oriental fruit moth	Curculio	Brown rot
Midseason Elberta ...	55%	23.70%	13.3%	19.8%
Gage Elberta	96%	2.50%	1.0%	1.0%

New Chemicals for Insect Control

J. J. Davis, Purdue University

Economic Entomology as a science is about 70 years old, and yet, largely because of the late war and the need of insecticides to protect our troops against disease-carrying insects in tropical areas, perhaps the last six or eight years have produced more progress in chemical insecticides than in all previous years.

We will briefly review the newer chemicals found effective in insect control and it should be noted that the next six or eight years will probably produce many more effective controls.

The new chemicals are rather specific in their action which emphasizes the fact that those who use these new materials must have a better understanding of them and their uses than of the insecticides previously recognized as standard materials.

A brief review of some of the chemicals which have shown most promise in pest control during the past few years is here presented and may give some idea of the future of pest control.

General Insecticides

DDT (dichloro diphenyl trichloroethane), the first and most publicized of the new organic chemical insecticides on the market. It is comparatively slow acting, has a residual effect that may last for several months, and is specific in its action. It is very effective as a residual insecticide against insects having sensory organs on their feet, including most flies, certain beetles and many butterflies and moths. It is effective against most household insects, such as fleas, bedbugs, and roaches; stored grain insects; body lice which carry such diseases as typhus; and many crop pests, including most potato, onion and cabbage insects, and the codling moth. On the other hand it is of little or no value against the Mexican bean beetle, squash bug, blister beetle, grasshoppers, plant lice and red spiders. Like many of the new organic insecticides, it is often harmful to curcubits.

Methoxychlor (methoxy analog of DDT) is not as toxic to man or insects as DDT, but controls Mexican bean beetle which is uneffected by DDT.

DDD (dichloro dipheny dichloroethane) is similar chemically and has about the same properties as DDT.

Benzene hexachloride (1, 2, 3, 4, 5, 6-hexachlorocyclohexane, $C_6H_6Cl_6$ and known also as 666) is a powerful insecticide and for many insects it is more toxic than DDT. It is effective against roaches, grasshoppers, tomato worms, animals, lice, ticks, mites and the cotton boll weevil. However, it leaves a musty odor and taste and is therefore objectionable in the home, and on crops which bear fruits.

Chlordane (a chlorinated hydrocarbon with the empirical formula $C_{10}H_6Cl_8$) is effective against many of the insects for which DDT is used but does not have as long a residual effect. It controls many household pests, especially ants, roaches, ticks, and spiders, and many crop pests, especially grasshoppers and thrips, are controlled with chlordane. Like DDT, chlordane injures curcubits.

"Toxaphene" and **"Phenotox"** are trade names of a chlorinated camphene with the empirical formula $C_{10}H_{10}Cl_8$. It is more toxic to man than DDT or chlordane. Highly toxic to many insects, more especially household insects, but also to many crop insects, especially grasshoppers.

Parathion (aryl alkyl thionophosphate), also known as 3422 a new chemical, gives a very quick kill, but at the same time is highly toxic to man. It has been highly effective against many insects, including roaches, cabbage worms, grasshoppers, blister beetles, plant lice and mites. It is one of the most promising of the new insecticides.

Hexaethyl tetraphosphate and **tetraethyl pyrophosphate** are two chemicals which have proven very effective against red spider and plant lice. They are highly toxic to man and should be used with every precaution and in enclosures such as greenhouses, respirators should be used.

Piperonol cyclohexenone and **Piperonol butoxide** are two chemicals which have proven to be valuable synergists with pyrethrum. More recent studies have shown that in addition to being vauable synergists that they possess appreciable toxic ingredients themselves.

Soil Insecticides

Sodium selenate is a chemical which, when applied to the soil, is taken up by the plant and kills certain insects feeding thereon. Thus, it has been found effective against certain important greenhouse pests, including red spider, aphids, chrysanthemum midge, and mites

"Soil Compound NC" (2 chloro, 6 nitrotoluene, with the empirical formula $C_7H_6NO_2Cl$). It is highly toxic to termites and decay fungi.

DD (Mixture of 1, 3-dichloropropylene and 1,2-dichloropropane). This soil insecticide has proven effective against such soil pests as nematodes and wireworms.

"Dowfume N" (a mixture of dichloropropane and dichloropropene) This is practically identical with soil insecticide DD.

"Dowfume W-10" (active ingredient ethylene dibromide) This is recommended at the rate of 20 gallons per acre for root nematodes and wireworms.

Fumigants

"Acrylon" (Equal parts by volume of acrylonitrile and carbon tetrachloride) Especially useful for local or "spot" treatments in mills for the control of infestations in the various units of flour machinery.

Perhaps its greatest usefulness will be in structures where it is imposible to conduct a general fumigation.

Azobenzene is a chemical fumigant developed for use in greenhouses where it seems especially useful in the control of red spider, thrips, aphids and white fly.

Rodent Poisons

Antu (Alphanapthylthiourea) is used in bait and as a tracking poison. Quite deadly to our common brown or Norway rat but less toxic to other species which seldom occur in Indiana. Less toxic to domestic animals than most other rodent poisons.

Compound 1080 (Sodium fluoroacetate) A highly toxic poison and for this reason is not available on the retail market nor is it recommended for use by anyone who is not trained in rodent control.

Insect Repellents

With the beginning of World War II and the need of protection of army personnel against disease carrying insects, thousands of chemicals were tested and three were selected as outstanding. These are:

1. **Dimethyl phthalate** This chemical was brought to light by the Standard Oil Development Company prior to the war. It is efficient as a mosquito repellent and especially against *Anopheles quadrimaculata.*

2. **Indalone** (Butyl mesityl oxi-oxalate) was found by Kilgore to be a good repellent for flies. Also efficient against some species of mosquitoes.

3. **Rutgers 612** (2-ethylhexanediol-1, 3) was developed in cooperation with the New Jersey Agricultural Experiment Station and the Bureau of Entomology and Plant Quarantine, by the National Carbon Company. It gives a long period of complete protection from *Aedes aegypti* and fairly good protection against other mosquitoes.

From the results of these studies a recommended repellent for flies and mosquitoes is a combination of the three chemicals referred to in the proportions of,

6 parts dimethyl pthalate
2 parts Indalone
2 parts Rutgers 612

This combination is also effective against chiggers, immature stages of ticks, sand flies, buffalo gnats and others.

Concluding Comments

In spite of the many new chemicals being developed for insect control, it should be noted that they do not necessarily supersede many of our old standard insecticides. The new materials do have limitations and as already stated, the user of these new chemicals must know these limitations and use accordingly.

Regardless of the number and value of new chemicals, they do not in the least minimize the importance of farm and home practices for preventing the development of insects to destructive numbers. Prevention is still the goal of entomologists for insect control. By the use of good farm practices, good housekeeping in the home, sanitation in food industries and proper building construction, insects may be reduced to a minimum and complete control will become a routine.

A final word regarding the correctness, thoroughness, and completeness of insecticide applications. The treater must know the how, when and where of insecticide application. Regardless of the equipment available, knowledge of the materials, procedures of application and the habits, life history, and structure of the pest in question is essential. In other words the final word depends on the individual applying the remedy, which emphasizes the increasing importance of service or custom operators. New equiment is now being developed and will increase insecticide efficiency, but there is no substitute for knowledge.

GEOLOGY AND GEOGRAPHY

Chairman: CHARLES F. DEISS, Indiana University

Dr. Floy Hurlbut, Ball State Teachers College was elected chairman of the section for 1948.

ABSTRACTS

An unusual occurrence of barite. S. M. MCCLURE, Eureka College, Eureka, Illinois.—Barite, as a compact crystalline filling in cracks and cavities of a septarium-like nodule or concretion, has been noted in the weathered Pennsylvanian shales near Peoria, Illinois. None of the nodules containing barite has been found in place but appear to have originated from nearby outcrops.

Indiana thunderstorms. STEPHEN S. VISHER, Indiana University.—The importance of thunderstorms in the overall picture of Indiana weather was discussed. Despite the excessively large losses from hail, lightening, and wind, the benefits which accrue from the acompanying rain far exceed the losses. Without the rainfall from summer thunderstorms Indiana would necessarily become a third rate agricultural state.

Standby power for line-operated recording equipment. RONALD L. IVES, Indiana University.—Simple and relatively inexpensive equipment for operating drive clocks and similar devices during failures of line power, and for switching this equipment in and out of operation automatically, is here outlined.

The lumbering industry of Morgan County, Indiana. JAMES R. ANDERSON, University of Maryland.—The location of Morgan County on the margin of the more heavily forested part of Indiana and near good transportation facilities and markets is relatively favorable to the continuance of a profitable lumbering industry. A report on the decline of the lumbering industry over most of the state was presented. The presence in parts of Morgan County of sizable areas ill adapted to farming but suitable to forest growth, makes it likely that lumbering will continue to be relatively important.

Soil conservation in Indiana. G. DAVID KOCH, Indiana State Teachers College.—The first soil conservation district in Indiana was organized in Vanderburgh County in February, 1940. On July 1, 1947 there was a total of 36 soil conservation districts in the state. These districts include a total of 7,793,985 acres or about one-third of the state. The author presented tables showing the increase of the number of districts by years, the location of districts, the rank of Indiana in relation to soil conservation in the neighboring states, and the types of soil conservation practices. Data were secured from the U. S. Soil Conservation Service.

Industrial limestones of northern Indiana. GEORGE E. ERICKSON, Indiana University.—The examination of the industrial limestones of northern Indiana was undertaken by the author in the summer of 1947 for the Division of Geology of the Indiana Department of Conservation. The purpose was to obtain complete information as to distribution, availability, chemical composition, and reserves. Rock is mined from nine geologic formations. The locations of the quarries and the uses of stone from various formations were discussed.

The changing relations of rivers to cities. OTIS P. STARKEY, Indiana University.—Most cities were founded along rivers which contributed to their early prosperity. Later canals were constructed to facilitate traffic. Many streams were used to float logs and to furnish power for numerous small mills. Forest exhaustion, floods, water pollution, and the rise of competing facilities have turned these once valuable rivers into traffic obstacles and potential dangers.

Imbricate structures in the Northern Rocky Mountains. CHARLES DEISS, Indiana University.—The sawtooth Range in northwestern Montana consists of a series of blocks of Middle Cambrian to Cretaceous rocks bounded longitudinally by closely spaced high angle thrust faults. In the eastern part of the Sawtooth Range the strata were broken into imbricated slices which rode eastward on a low angle thrust sole. In the central part of the range deformation was more intense and resulted in closer spaced, high-angle thrusts and narrower slices composed largely of Devonian and Mississippian limestones which locally were dragged into recumbent folds on the upturned sides of the thrust slices. Deformation was greatest in the western part of the range where folded low-angle overthrusts, open and closed folds, and a few high-angle thrusts were developed.

The great amount of movement and the shallowness of the affected zone may indicate that the east foreland of the geosyncline moved west and was the source of the stress. If this conclusion is correct, the faults are underthrusts instead of overthrusts as they have been described by all workers in the northern Rocky Mountains.

Advent of the lower Puerco fauna, San Juan Basin, New Mexico. THOMAS E. REYNOLDS, Valparaiso University.—The lower Puerco sediments contain the earliest record of fossil mammals to appear in such an advanced stage of differentiation on the North American continent. The possibility that they were migrants from some upland fauna was discussed. Their origin being some Central Asiatic focal point, arriving by land bridge from the North. Further evidence for such an origin was deduced from several type specimens (*Puercolestes simpsoni* and *Escatepos campi*) collected by the author in the bad-lands of New Mexico.

The Geology of the Dicksburg Hills, Knox County, Indiana

Clyde A. Malott, Indiana University.

In the counties bordering the Wabash River in southwestern Indiana very few studies have been made which clearly depict the character and succession of the formations of the upper Pennsylvanian series forming the areal geology inward from the eastern margin of the Illinoian basin. Several factors have combined to make studies of the surface bedrock formations rather difficult in much of Posey, Gibson, Knox, and parts of Sullivan and Vanderburgh Counties. No coals of commercial thickness occur above the Millersburg coal (Coal VII), and the economic incentive has been small. The deep alluvial materials of the broad floor of the Wabash River and the adjacent mantle of dune sands and loess flanking the upland on the east form such an effective cover that rock exposures are few. Thick silts of lacustrine deposits extend up many valleys and often expand in extensive flats leaving no rock formations uncovered over wide areas. Also glacial drift is an effective cover over much of the area of the Wabash River counties. Most of the prominent exposures, such as those at Merom Bluff in Sullivan County, at old Fort Knox, Chimney Hills, and the Dicksburg Hills in Knox County, at Bald Hill and Skelton Cliff in Gibson County, at the New Harmony Cut-off, Brewer Hill, and Bufkin in Posey County, are mere key-hole glimpses of various sandstones, which, in their isolated exposures, exhibit very similar characteristics and in themselves are only doubtfully distinguishable. The intervening shale formations, containing the stratigraphic markers of the thin coals, black sheety shales, and thin limestones, are usually only about one-half the thickness of the massive sandstones and are much less ostentatiously exposed. They are so susceptible to weathering and erosion that they rarely exhibit vertical faces and are usually covered. The best exposures of these more diagnostic beds are found usually in the bottoms of creek beds in steep ravines, and only rarely do they occur at the foot of the bluff-like sandstone exposures. Still another difficulty in the study of the surface formations is the tendency of many of the sandstones to become shaly and lose their characteristics as massive sandstones. Also some of the more diagnostic beds, such as the marine limestones, thin out or disappear in one direction or another. For instance, the well known West Franklin limestone, 200 feet or more above the Millersburg coal (Coal VII), is not known to outcrop in Knox County. The Maria Creek limestone, extending along the outcrop through eastern Sullivan County about 75 feet above the Millersburg coal (Coal VII), disappears southward near Bicknell and the beds above it and below it merge without a stratigraphic marker.

The region of the Dicksburg Hills in southern Knox County exhibits some of the difficulties of a study of the surface formations in the upper Pennsylvanian of southwestern Indiana, but, because of certain

circumstances in its geomorphic development, some rather excellent rock exposures occur which permit a study of several formations in that locality. It is the purpose of this paper to present the details of some of these exposures and to establish the stratigraphy and nomenclature, not only for the rocks of the locality, but for all the area of southwestern Indiana which comes within the same stratigraphic range.

Location and Physiography

The Dicksburg Hills are two prominent hilly masses which rise abruptly above the broad alluvial plains of the Wabash and White Rivers in the extreme southern part of Knox County, about 12 miles south of Vincennes, Indiana. The village of Hazelton is just across White River in Gibson County one or more miles to the southeast, and Decker is a similar distance to the northeast. U. S. Highway 41, between Vincennes and Princeton, passes along the east side of the eastern isolated hill, where a roadside park is maintained by the Indiana Highway Division. White River comes out of the upland from the east in a valley a mile wide and makes a northward loop which cuts directly into the broad Wabash alluvial plain. It turns back into its own valley, skirting closely the eastern hill as it does so. Thence, it turns westward, passing south of the two Dicksburg Hills, and enters the broad alluvial plain of the Wabash Valley which here is 7 or 8 miles in width. See figure 1.

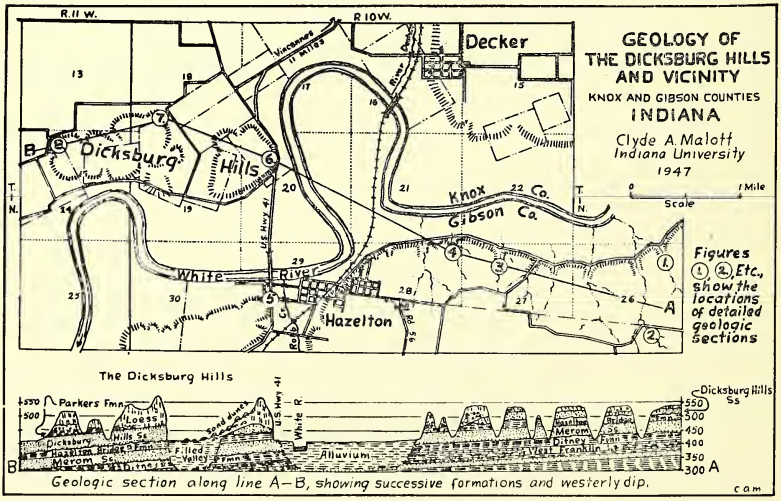


Fig. 1. Map of the Dicksburg Hills locality with cross-section depicting the upper Pennsylvanian formations present in the region.

The Dicksburg Hills are specially severed and isolated sections of the nearby upland. They have a bedrock foundation which has been covered with Illinoian drift, encroached upon by dune sands and heavily mantled by loess. The eastern hill occupies an area of about 200 acres and has a

variable topography of mantling sand and loess. It culminates in a hill crest near its eastern edge which rises 150 feet above the alluvial plains of the Wabash and White Rivers. The western hill, with a similar mantle of loess and encroaching dunes, is a rugged tract of about 325 acres. It is separated from the eastern hill by a strip of lake silts about half a mile in width which is partly covered with wind-blown sands and dune hillocks. The upland surface of the western hill, composed of loess, has been deeply eroded, and its highest hill crests also rise 150 feet or slightly more above the surrounding floodplain area which has an altitude of 405 to 410 feet above sea level. The bedrock aspects of the hills are clearly discernible only on the northern and eastern sides. The geographic and topographic aspects of the region are depicted on the Vincennes, Princeton, and Petersburg quadrangles of the U. S. Geological Survey, which served as the basis of the sketch map shown in figure 1.

The Dicksburg Hills, with their mantles of glacial drift, dune sand, and loess, are good examples of many such isolated hills in the broad alluviated valley of the lower Wabash River. They have been described by Fidlar (1933, 135; 1936, 178) as whittled-down remnants of land masses severed from the upland along and adjacent to the Wabash where the great volumes of melt-waters of the Wisconsin glacial epoch encroached upon the uplands and cut out great valley fluves or valley braids, which upon being widened left the bedrock hills with their topping of Illinoian drift, sand dunes, and loess within the expansive valley plain. Fidlar (1935, 60-62) expressed the belief that White River formerly entered the Wabash Valley in the wide opening just west of Decker, and was later diverted to the route south of the Dicksburg Hills. He suggests that the strip of lacustrine floor at an altitude of about 435 feet between the two Dicksburg Hills was once connected with the lake plain of Robb Creek which now enters White River just west of Hazelton. A study of the topography revealed by the Vincennes and Iona quadrangles leads to the conclusion that the course of White River was formerly north of Decker. A dune-clogged valley 2 miles or more in width joins the Wabash Valley north of Decker. This vacated valley extends eastward and connects directly with the wide valley of White River. Some 2 miles northeast of Decker, the present river turns southward from its wide valley and enters one only half as wide, which it follows for about 5 miles before entering the Wabash Valley west of Hazelton. The bluffs along this stretch of White River Valley are rather abrupt, and the ravines coming in from the upland on the south are narrow and have bedrock floors to their debouchures into the river valley, a condition expressive of rejuvenation. Also bedrock is present in the bed of White River itself both at Hazelton and a half mile west of the bridge at Hazelton. Why White River should have been diverted southward into a new course is not clearly evident. The union of the alluvial plains of the Wabash and White Rivers between Decker and the Dicksburg Hills was a matter of lateral planation and was incidental in severing the Dicksburg Hills from another sand- and loess-covered bedrock mass east of Decker and south of the earlier broad course of White River.

Stratigraphy

The upper Pennsylvanian series in Indiana begins with the persistent Anvil Rock sandstone a short interval above the Millersburg coal (Coal VII), the highest of the more widely mined coals in the middle series. The upper series aggregates a thickness of about 500 feet and is composed of 12 or more stratigraphic units south of White River in southwestern Indiana.

The geologic formations exposed locally in the Dicksburg Hills and in the bluffs at Hazelton and eastward for 3 miles consist of several formational units within the upper Pennsylvanian series. Two of them receive their names from the region, while four others have been named from other localities and extend through the region. The formations will be described in this paper in their natural stratigraphical order. Since the formations dip gently westward, the lower formations are exposed on the east and the higher on the west. See geologic section, A-B, figure 1.

West Franklin Limestone. The West Franklin limestone is exposed at two or three places in the bed of a small creek in the NE¼ sec. 26, T. 1 N., R. 10 W., 3 miles east of Hazelton. The best exposure extends across the bed of the creek and is much dissolved along the rather close-spaced joints. It is a hard, fossiliferous bed about 2 feet thick. Only the upper member is exposed. It is uncertain that the lower member extends this far north. Only the upper member has been observed in the Mt. Olympus locality, some 3 or 4 miles southward. South of the Patoka River, the West Franklin limestone is a well known double bed of limestone about 200 feet above the Millersburg coal (Coal VII). Its outcrop is shown across parts of the Ditney and Patoka quadrangles of the U. S. Geological Survey, where it is described under the name "Somerville formation" by Fuller (1902, 2 and 1904, 2). Normally it consists of a lower bed of brecciated limestone 5 to 10 feet in thickness and an upper bed 2 to 5 feet in thickness. The two beds are usually separated by shale ranging from 2 to 15 feet in thickness. It is not definitely known to outcrop north of White River throughout Knox County. The name of West Franklin limestone was first applied to this formation by Lesquereux (1862, 294, 297) from the excellent exposures in the bluff of the Ohio River at West Franklin in the southeast corner of Posey County, Indiana, and later it was used by Collett (1884, 61-62). This name was restored to it by Shrock and Malott (1929, 1301-1302) and the name "Somerville" was dropped.

Ditney Formation. While it is believed that the best procedure for the division of the upper Pennsylvanian series into its natural stratigraphic units should be based upon the recognition that the massive sandstones constitute individual units of one type and the shales, thin coals, black sheety shales, limestones, etc., constitute a second type of formation, certain exceptions should be made. The West Franklin limestone would normally become a member of the second type of formation lying between a sandstone occurring about 10 feet below it and the massive Merom sandstone from 0-35 feet above it. Because of the importance of the West Franklin limestone as a stratigraphic marker at the outcrop and

in the subsurface to the west, it is believed best to consider it as a stratigraphic unit in itself rather than as a member of a formation. Hence, the strata above it and below the Merom sandstone must be recognized as a formation. To this formation Fuller (1902, 2) applied the name Ditney, from the locality of the Ditney Hills, about 25 miles south of the Hazelton locality. This name is retained for these beds. They are well exposed along the bluff and in the ravines in sec. 26, especially in the NE¼, 3 miles east of Hazelton. There the Ditney formation measures 33 feet in thickness and is composed mainly of shales containing ferrous carbonate concretions and bands, near the bottom of which is a coal bed 14 inches thick topped by a black sheety shale and an impure limestone clod. A detailed section is given below. (See section 1.) Farther south the formation consists of a shale 12 to 20 feet in thickness with ferrous carbonate concretions and locally beds of firm sandstone, followed by the underclay, thin coal and the black sheety shale, and locally a still higher shale a few feet in thickness. In many places, however, the upper part of the Ditney formation has been eroded and the Merom sandstone rests upon the lower part of the formation with a marked disconformity. In some places the Ditney formation is entirely gone and a part of the West Franklin is also missing along this marked unconformity.

Merom Sandstone. The Merom sandstone is well exposed in the White River bluffs and in the ravines in sections 26 and 27 east of Hazelton, and shows of its upper massive portion occur in White River and in Robb Creek just east of White River bridge of Hazelton, and the top of it shows near road level at the Dicksburg Hills roadside park. It is also exposed in the artificial channel of diverted River Deshee for 1,000 feet on either side of the bridge just west of Decker. It is well exposed to the southeast of Hazelton in sec. 36, T. 1 N., R. 10 W., and southward to the Mt. Olympus locality. It is about 40 feet thick in the Hazelton locality. Its base does not exhibit its usual unconformable relationship on the beds below, such as is the case farther south and in the exposures north of Vincennes, and there is not the usual few inches of iron ore concentration containing sand and shale pebbles. In fact, in the Hazelton locality its basal portion appears quite conformable on the Ditney shales below, and its basal portion, while soft and micaceous, is locally shaly. Its shaly aspects, however, exhibit the usual marked cross-bedding so characteristic of the massive sandstones of the Pennsylvanian system. The Merom sandstone is everywhere a soft, massive, cross-bedded sandstone rarely exhibiting normal bedding. It is composed of coarse, angular, vitreous quartz grains, mica flakes, and considerable intergranular kaolin. The occurrence of the latter is probably responsible for its soft friable condition.

The Merom sandstone was named from the exposures of massive sandstone in the Wabash River bluff at Merom in western Sullivan County, Indiana, by Collett (1871, 199-200, 208), and, next to the West Franklin limestone was the first individual stratigraphic unit to receive a name in Indiana. Later Collet (1872, 243, 250; 1874, 320-324, 332, 334,

355, 286-389; 1876, 251-258, 272-281) traced the Merom sandstone southward through Knox, Gibson, and Vanderburgh Counties to the Ohio River. It is 35 to 40 feet thick in its type locality at Merom and maintains a similar thickness throughout its outcrop area. Locally it may reach a thickness of 50 feet or slightly more. While the Merom and Graysville exposures in the type region of the sandstone are separated from the extensions of the formation, the continuity of the sandstone may be traced southward from near Hutsonville and Palestine through Crawford County, Illinois, and thence across the Wabash River to the old Fort Knox locality, near where it passes below the Wabash River just north of Vincennes.

Fuller (1902, 2), because of some expressed doubts concerning its correlation in the Ditney Quadrangle area south of White River, included the Merom sandstone in his "Inglefield" sandstone, and this name was continued by Fuller and Clapp (1904, 2) in the area of the Patoka Quadrangle on the west. Since the sandstone at Inglefield in Vanderburgh County, 10 miles north of Evansville, is the same as the Merom sandstone, Cumings (1922, 525) dropped the name Inglefield. Fuller's "Inglefield formation", however, included the shales, thin coal, etc., and another higher massive sandstone which were given separate names by the present writer some years ago (Malott, 1939, 114).

Hazelton Bridge formation. The name Hazelton Bridge formation (Malott, 1939, 114) has been applied to a shaly formation some 20 to 25 feet in thickness, consisting of shales with ferrous carbonate concretions, a hard calcareous sandstone or a thin fossiliferous limestone, and one or two thin coals with or without black sheety shales above them, which lies between the Merom sandstone below and a similar massive sandstone above. The type locality of this formation is from an exposure at road level in White River bluff just south of the White River bridge west of Hazelton on U. S. Highway 41 in northern Gibson County, Indiana. The formation here was well exposed a few years ago, but at present it is partly covered and rather obscure. The exposure of the formation on the east bluff of the Dicksburg Hills is likewise partly covered. Good exposures, however, are still preserved in some of the river bluff ravines in sections 26 and 27 east of Hazelton. The characteristics of the formation are given in several detailed sections presented in the latter part of this paper.

The Hazelton Bridge formation shows above the Merom sandstone as a poorly exposed shale at old Fort Knox, 2 miles north of Vincennes, and its shales, thin fossiliferous limestone, thin coal, and black sheety shale show above road level along the eastern side of the Robeson Hills, eastern Lawrence County, Illinois, just across the Wabash River from Vincennes. Southward from its type locality it is seldom exposed. It has been observed, however, in a ravine east of Bald Hill, 2 miles north of Princeton, and numerous exposures of its shale and its thin coal have been noted in Vanderburgh County northwest and west of Evansville, where it lies 80 to 90 feet above the West Franklin limestone.

Dicksburg Hills sandstone. In the east bluff of the Dicksburg Hills some 25 feet or more above the U. S. Highway 41, a massive, coarse-grained, micaceous, friable, cross-bedded sandstone rests on the Hazelton Bridge formation. Only a few feet of the sandstone are exposed there. In the western hill, especially in the southwest part of sec. 18, this massive sandstone is well exposed, and at "The Rock Bluffs" fully 50 feet of it is exposed. Its top, capped by a shale, shows some 15 feet above road level in the NENW¼ sec. 24. As much as 35 feet of it is exposed in a ravine in the NW part of sec. 27, about 2 miles east of Hazelton. Farther south this sandstone was mapped as a part of Fuller's "Inglefield formation" in the Ditney and Patoka folios of the U. S. Geological Survey. It was named the Dicksburg Hills sandstone by the writer (Malott, 1939, 114) from the exposures in the Dicksburg Hills of southern Knox County. It composes the soft, micaceous, cross-bedded sandstone exposed locally near the base of the Chimney Hills to the north of the Dicksburg Hills, the small sandstone remnant known as "La Mamelle" in the NW part sec. 14, T. 2 N., R. 11 W., and the abrupt western bluff of the Wabash River at St. Francisville, Illinois, where it was formerly thought to have been the Merom sandstone (Collett, 1874, 324, 338; Fidlar, 1933, 137-139). Southward, many exposures are known where it appears above the Hazelton Bridge formation. It is well exhibited in the railway cut under the overhead bridge in the northern part of sec. 22, T. 5 N., R. 11 W., about 8 miles northwest of Evansville and a mile or so northeast of St. Joseph, and occupies the ridges about Kasson just northwest of Evansville.

The Dicksburg Hills sandstone in the area near its type locality is a very coarse sandstone, especially in its lower part. Its base is unconformable on the Hazelton Bridge formation and is composed of very coarse vitreous quartz sand much of which is quite angular, showing little evidence of wear. Some of the angular quartz grains exceed $\frac{1}{16}$ of an inch across, and, along with soft clay pebbles, the basal part of the formation contains much white kaolin in grain-like form or as fillings between the quartz grains. The kaolin in the sandstone is probably an alteration product from grains of feldspar deposited as a part of the formation. If such an interpretation is correct, the sandstone originally was an arkose. It is the writer's belief that the soft or friable condition is caused and maintained by the intergranular kaolin constituent in this and similar sandstones. It is not an uncommon thing to find intergranular white kaolin distributed through the coarse, soft, micaceous sandstones of the Pennsylvanian system, including portions of the Mansfield sandstone and several of the sandstones in the middle series. It is especially conspicuous in the Merom and Dicksburg Hills sandstones. These sandstones in places are merely altered arkoses, and the materials composing them must have come more or less directly from granitic rocks, though such sources are not immediately apparent.

Parkers formation. The Parkers formation has a thickness of 25 to 30 feet or more. It consists mainly of shales, but also of some thin sandy beds near the base, two thin coals with the one near the top capped

by a black sheety shale, and usually a fossiliferous limestone. This upper coal is the Parkers coal of the formation. The Parkers formation rests on the Dicksburg Hills sandstone and is succeeded by the St. Wendells sandstone, a name long used in the field by the writer and used in the columnar section of the Geologic Map of Indiana (Logan, 1932), the name coming from the village of St. Wendells on line between Vanderburgh and Posey Counties about 10 miles northwest of Evansville. The name Parkers formation is derived from Parkers Settlement in eastern Posey County, Indiana, about 8 miles northwest of Evansville on State Road 66. The name is a variation of the name Parker, used for the coal, black sheety shale and limestone of the upper part of the formation by Fuller and Clapp (1904, 2-3) in the Patoka Folio of the U. S. Geological Survey. The outcrops used by these authors occur in the hills east of Parkers Settlement, mainly in the western edge of Vanderburgh County. The Parkers formation fills a space between the Dicksburg Hills and the St. Wendells sandstones, very similar to that of the Hazelton Bridge formation between the Merom and Dicksburg Hills sandstones. The very thin coal near the base of the Parkers formation is a very distinct stratigraphic marker a few feet above the Dicksburg Hills sandstone. This coal is very frequently only a smut streak and usually not more than one inch thick. It has a very persistent underclay 2 or 3 inches thick and is overlaid with a clay band or a ferrous carbonate band about one inch thick. This band contains numerous shells and shiny imprints of *Estheria* which help make this horizon a very distinct and elegant stratigraphic marker. This marker I have called the Rabens Branch bed, named from an excellent exposure in Rabens Branch, a small stream crossing the north-south road about a quarter of a mile south of the center of sec. 11, T. 5 S., R. 12 W., 1½ miles southwest of St. Wendells, Posey County, Indiana. The outcrop extends along the bed of this small stream with all members well displayed. The Rabens Branch horizon is about 20 feet below the Parkers coal and its black sheety shale, both of which are well exposed farther up the stream. The exposures of this thin marker are relatively numerous in the St. Wendells region. The same thin marker is exposed at several places with similar characteristics south of the road along the north side of the hill in the NENW¼ sec. 24, of the Dicksburg Hills locality, some 28 miles north and 7 miles east of the type locality. Only the lower part of the Parkers formation is exposed here, consisting of a few feet of shale, the Rabens Branch horizon, and a few feet of shale and sandy beds above. Gravelly Illinoian glacial drift rests on the bedrock of this locality. Some loose limestone blocks, resembling the Parkers limestone, were noted on the south side of the western hill less than one-half of a mile to the southeast, indicating the possibility of the presence of the higher part of the Parkers formation under the cover of glacial drift and the thick deposits of loess.

Detailed Geologic Sections

The following detailed rock sections are given to show the character of the geologic formations and to establish their succession in the Dicksburg Hills region. Only rarely are the formations exposed well

enough to permit their identification as individual stratigraphic units or to demonstrate their sequential succession in the stratigraphic column. The sections will be presented from east to west in the order of their rise in the stratigraphic column. Some of the sections are from spot exposures, but most of them are built up from exposures along ravines extending as much as a quarter of a mile or more, or are composed of a number of individual exposures. The sections are shown graphically in figure 2.

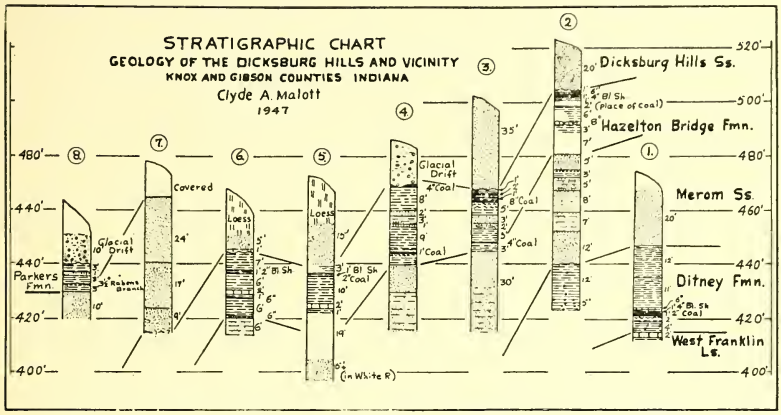


Fig. 2. Upper Pennsylvanian sections in the Dicksburg Hills locality. Section numbers correspond to the locations shown on the map of Figure 1.

Section 1. Exposures in creek bed and western bluff of stream running through the NE¼ sec. 26, T. 1 N., R. 10 W., 3 miles east of Hazelton.

	Ft.	in.
10. Covered slope		
Merom sandstone		
9. Massive, cross-bedded, friable, micaceous sandstone containing intergranular kaolin	20	
Ditney formation		
8. Gray shale with some ferrous carbonate concretions	12	
7. Dark shale with numerous ferrous carbonate concretions and bands	11	
6. Dark, calcareous shale, "calcareous clod," fossils abundant		6
5. Black sheety shale	1	4
4. Coal (Ditney coal)	1	2
3. Light-gray shale, becoming underclay at top	2	
2. Gray shale with ferrous carbonate concretions	4	
West Franklin limestone		
1. Hard, fossiliferous limestone bed	2	

The section given above begins with the top member of the well known West Franklin limestone which is an important stratigraphic marker about 200 feet above the base of the upper Pennsylvanian series in southwestern Indiana. It is exposed in the bed of the creek just south of the road where the creek enters White River Valley, but the best exposure is in the creek bed about 300 yards to the southeast. The remaining part of the section was taken from a ravine entering from the west, and in the creek bed and the western bluff farther southeast. The Ditney coal here is closer to the West Franklin limestone than in the exposures of the Ditney formation farther south in Warrick and Vanderburgh counties. The Ditney formation here is 33 feet in thickness. This is somewhat greater than observed farther south. The massive Merom sandstone rests abruptly on the Ditney formation but does not exhibit its usual disconformable relationship. It is highly cross-bedded and contains considerable intergranular kaolin throughout.

Section 2. From exposures in the road and in the ravine, SE¼ sec. 26, T. 1 N., R. 10 W., 3 miles east of Hazelton.

	Ft.	in.
Dicksburg Hills sandstone		
18. Coarse, gritty, friable, cross-bedded, micaceous, gray sandstone, composed mainly of angular vitreous quartz grains with incorporated clay pellets in the base, some pyrite and carbonized plant fragments, and well impregnated with kaolin throughout	20	
Hazelton Bridge formation		
17. Dark clay shale	1	
16. Dark, calcareous "clod" or limestone, fossils		6
15. Black sheety shale	1	4
14. Dark clay shale	1	
13. Covered (place of coal)	2	
12. Shows of gray shale	6	
11. Hard, impure, bouldery limestone		8
10. Shows of gray shale	3	
9. Covered	7	
Merom sandstone		
8. Coarse, soft, cross-bedded, micaceous sandstone	5	
7. Gray shale with smut streak and thin underclay near top	3	
6. Soft, shaly, micaceous, cross-bedded sandstone	5	
5. Soft, cross-bedded, micaceous sandstone	8	
4. Soft, shaly, cross-bedded, micaceous sandstone	7	
3. Soft, cross-bedded, micaceous sandstone, with streaks of coal at various angles and fossil plant impressions near base	12	
Ditney formation		
2. Gray shale, slightly sandy, ferrous carbonate concretions	12	
1. Dark shale with abundant ferrous carbonate concretions and bands	5	

The Merom sandstone in the above section was measured from the outcrop up the hill in the road from the ravine where the road turns eastward. The Merom sandstone is fully 40 feet thick. The smut streak and thin underclay near the top has not been observed elsewhere. The Hazelton Bridge formation appears to be about 22 feet in thickness, and most of it is well exposed in the ravines to the southeast of the road turn where the Merom is well exposed. The coal near the top was not seen, though at several places excavations had been made in attempts to mine it. As much as 20 feet of the Dicksburg Hills sandstone is exposed in the very head of the sharp ravines entering from the east. Water continually seeps from the base of this sandstone, and the rock is still its original gray color. It is soft, friable, very coarse, micaceous, cross-bedded, and well impregnated with white kaolin. The kaolin particles are very soft when wet, but in the dry specimens of the sandstone the kaolin gives a mealy feel and appearance to the sandstone. The elevation of the base of the Dicksburg Hills sandstone in the section is approximately 505 feet above sea level.

Section 3. Compiled from exposures in and along the ravine, NW¼ sec. 27, T. 1 N., R. 10 W., 1¾ miles east of Hazelton.

	Ft.	in.
Dicksburg Hills sandstone		
12. Coarse, soft, micaceous, cross-bedded, yellow sandstone	35	
Hazelton Bridge formation		
11. Soft, dark clay shale	1	
10. Black sheety shale	2	
9. Dark clay shale	1	
8. Coal		8
7. Light gray clay shale becoming underclay at top	5	
6. Hard, micaceous, lime-bound sandstone	3	
5. Soft, thin-bedded sandstone, shaly	2	
4. Gray shale	5	
3. Coal		4
2. Sandy shale	3	
Merom sandstone		
1. Soft, cross-bedded, micaceous sandstone, shaly in lower part	30	

The Merom sandstone is well displayed along the valley bluff and in the lower part of the ravines in the northern part of sec. 27. Some parts of it are shaly, though remaining cross-bedded. The Hazelton Bridge formation in the section is completely exposed with all of its members and totals 23 feet in thickness.

Section 4. Compiled from exposures in ravine in the NENE¼ sec. 28, T. 1 N., R. 10 W., 1¼ miles east-northeast of Hazelton.

	Ft.	in.
12. Illinoian glacial drift		

		Ft.	in.
Hazelton Bridge formation			
11.	Shows of black sheety shale		
10.	Coal		4
9.	Gray shale	8	
8.	Hard, micaceous, calcareous sandstone	2	
7.	Shaly sandstone	3	
6.	Hard, micaceous, calcareous sandstone	1	
5.	Gray shale with ferrous carbonate concretions	9	
4.	Shaly or "bony" coal	1	
3.	Soft gray shale, becoming underclay at top	4	
Merom sandstone			
2.	Soft, cross-bedded, micaceous sandstone	10	
1.	Shaly, micaceous, cross-bedded sandstone	15	

In section 4, glacial drift rests on the Hazelton Bridge formation very near the top. The formation appears to be slightly in excess of 28 feet. Large blocks of fossiliferous limestone rest close on the top of the Merom sandstone on the point of the spur east of the ravine a short distance south of the road at the mouth of the ravine. They are likely erratics in the glacial drift which has been nearly washed away at this place.

Section 5. Composite section in bluff and bed of Robb Creek at or near the intersection of U. S. Highway 41 and State Road 56, south of the Hazelton Bridge across White River just west of Hazelton. Middle western ½ of sec. 29, T. 1 N., R. 10 W.

		Ft.	in.
Dicksburg Hills sandstone			
9.	Massive, coarse, cross-bedded sandstone, base not observed	15	
Hazelton Bridge formation			
8.	Shows of gray shale	3	
7.	Black sheety shale containing *Estheria*	1	
6.	Smutty shale with coal streaks		2
5.	Gray shale	10	
4.	Yellow, impure, fossiliferous limestone	2	
3.	Shows of gray shale	1	
2.	Covered	19	
Merom sandstone			
1.	Coarse, cross-bedded, friable sandstone	5	

This section is now rather poorly exposed. It is the type section for the Hazelton Bridge formation. The yellow, fossiliferous limestone is apparently in the place of the hard calcareous sandstone in the sections east of Hazelton. Much of the limestone at road-level, formerly well exposed on the east side of U. S. Highway 41 a short distance south of the intersection with State Road 56, has been excavated and removed.

The Merom sandstone in the bed of Robb Creek and in White River above the bridge is probably as much as 10 feet below the top of that formation. The Hazelton Bridge formation is probably about 25 feet in thickness. The Dicksburg Hills sandstone is only partially exposed along the bluff west of the highway, and neither the top or the bottom is shown.

Section 6. Along the east bluff of Dicksburg Hills, west side of U. S. Highway 41, NW¼ sec. 20, T. 1 N., R. 10 W., 1 mile north of the White River bridge at Hazelton.

Dicksburg Hills sandstone	Ft.	in.
11. Soft, mealy, micaceous, cross-bedded, coarse sandstone	5	
10. Coarse, ferruginous sandstone, incorporating clay pellets, kaolin lumps and kaolin particles, all rather porous with some rather large holes and cavities	1	
Hazelton Bridge formation		
9. Gray shale	7	
8. Black sheety shale with scattered *Estheria*	1	2
7. Gray shale	6	
6. Impure, fossiliferous limestone, cloddy to hard with small brachiopods gastropods and crinoid stems, 6 inches to	2	
5. Gray shale	1	
4. Smutty shale with coal streaks		6
3. Gray shale	6	
2. Hard bed of ferrous carbonate concretions and bands		6
Merom sandstone		
1. Hard shaly sandstone at or near road level	6	

In this section only the base of the Dicksburg Hills sandstone is exposed. It is at an elevation of about 445 feet above sea level. The Hazelton Bridge formation is 25 feet in thickness. Here again the impure limestone replaces the hard calcareous sandstone found east of Hazelton. While this section was well exposed some years ago, it is now partially grown over and covered with its own weathered debris. The upper coal does not show. It was reported present along the highway near the north end of the Dicksburg Hills roadside park when excavations were made there some years ago.

Section 7. Exposures in "The Rock Bluffs," SW¼ sec. 18, T. 1 N., R. 10 W., in the northeastern part of the western hill of the Dicksburg Hills, Knox County, Indiana.

Dicksburg Hills Sandstone	Ft.	in.
4. Covered		
3. Massive, cross-bedded sandstone, rather soft beneath a case-hardened surface, weathered yellow and has some surface iron concentration on overhang beneath lip of intermittent waterfalls	24	

2. Massive, cross-bedded, micaceous, coarse-grained sandstone, somewhat case-hardened and has large niche-like cavities weathered out in the overhang of the intermittent waterfalls and considerably undercut at the base. Contains much intergranular kaolin particles 17
1. Very coarse, gray sandstone, containing much white kaolin and near the base many included shale and clay pellets, all only partially exposed and in the zone of water seepage at base of intermittent waterfalls 9

Here the Dicksburg Hills sandstone is the only formation exposed, and it is fully 50 feet in thickness. This may be regarded as the type section of the Dicksburg Hills sandstone. More than 30 feet is exposed in the overhang of the intermittent waterfalls. The base was not actually observed, but the rock with the clay and shale pellets in the very coarse, kaolin-impregnated sandstone below the waterfall pit is believed to be near the base of the formation. The altitude here is about 415 feet above sea level.

Section 8. Exposures south of the road and in a small ravine leading west at the northwest edge of the western Dicksburg hill, NENW¼ sec. 24, T. 1 N., R. 11 W.

	Ft.	in.
11. Steep faces of calcareous Wisconsin loess with bands of gastropods in wash, about	15	
10. Covered, about	15	
9. Yellow, gravelly, Illinoian glacial drift, about	10	
Parkers formation		
8. Gray shale with local patches of disordered and broken fossil plants	3	
7. Hard, laminated, fine-grained, micaceous, rusty sandstone	1	
6. Gray shale, slightly sandy	3	
5. Clay band, rusty, containing *Estheria*		1
4. Smut streak with local shows of coal		½
3. Underclay		2
2. Gray shale	3	
Dicksburg Hills sandstone		
1. Soft, micaceous sandstone with shows of bedding near top	10	

Section 8 shows the top of the Dicksburg Hills sandstone which here is about 430 feet above sea level, or about 15 feet lower than the base of the formation at the eastern side of the hills 2 miles to the east. Assuming that the Dicksburg Hills sandstone is 50 feet thick, these data indicates a westward dip through the hills of 65 feet, a somewhat greater dip than is indicated in the bluffs east of Hazelton. The thin Rabens Branch stratigraphic marker is well exhibited at several places in the outcrops, and possesses about the same characteristics here as in the type locality

some 25 or 30 miles to the south. It is described under 2, 3, and 4 of the above section.

Summary and Conclusion

The Dicksburg Hills region in southern Knox County and the adjacent bluffs and ravines across the White River near Hazelton in northern Gibson County compose an area which, because of its rather unusual geomorphic development, possesses much better rock exposures than is common throughout much of southwestern Indiana where the upper Pennsylvanian beds form the surface rocks. The present course of White River runs somewhat south of an older, clogged course north of Decker, and the sharply-cut southern bluffs of the newer course east of Hazelton and the rejuvenated ravines adjacent show good exposures of the rock formations. The Dicksburg Hills, now north of the newer course of White River, have been laterally planed by the glacial floods of Wisconsin time, and the eastern and northern sides of these isolated and circumalluviated hills have bold bluffs of exposed rock, though much of their area is covered with Illinoian glacial drift and the dune sands and loess of Wisconsin time.

Parts or all of six stratigraphic units are exposed in an aggregate of about 160 feet of rock strata in the Dicksburg Hills and the bluffs and ravines south of White River east of Hazelton. Two of these formations, the Hazelton Bridge formation and the Dicksburg Hills sandstone, receive their names from the locality. Four other formations extend through the locality, having received their names elsewhere. The rock formations show a westerly dip amounting to 125 feet in a distance of 6 miles, 65 feet of which is through the Dicksburg Hills which extend only 2 miles in an east-west direction.

The top member of the West Franklin limestone, exposed 3 miles east of Hazelton, is the lowest stratigraphic unit exposed in the locality. It is succeeded by the following formations in order of their succession: Ditney formation (33 ft.), Merom sandstone (40 ft.), Hazelton Bridge formation (24 ft.), Dicksburg Hills sandstone (50 ft.), and the Parkers formation (10 ft. exposed). The characteristics and habits of these formations are presented in some detail in this paper, and carefully measured sections showing them in order are given for the Dicksburg Hills and Hazelton localities.

The Merom and the Dicksburg Hills sandstones typically are soft, friable, cross-bedded, micaceous sandstones, the basal parts of which are usually quite coarse and contain incorporated shale pellets and considerable intergranular kaolin. This is more apparent in the Dicksburg Hills sandstone than in the Merom sandstone of the locality. These sandstones are distinctly unconformable on the beds upon which they rest. Locally, considerable iron oxide is incorporated in the basal parts of these sandstones. It is believed that this iron oxide is secondary, having been derived through the alteration of pyrite which is abundant in the basal parts where it has not been altered.

The shales, thin coals, and limestones of the formations between the massive sandstones represent beds which have accumulated rather

slowly. They are largely indigenous beds which accumulated in waters that had little movements. The coals, limestones, ferrous carbonate concretions and bands, and, to a certain extent, the black sheety shales and the underclays, are organic and chemical in origin. The shales are composed of muds which did not come from long distances and are largely redepositions. Even the sandstones and sandy beds in these formations accumulated rather slowly and are probably redepositions from local origins. They are usually well bedded, firm or hard, and are frequently laminated rather than massive and cross-bedded.

The massive sandstones, on the other hand, bear evidence of rapid accumulation in strongly moving currents. The coarseness and angularity of the quartz grains, the presence of considerable mica, and the occurrence of the intergranular kaolin, probably derived from feldspar, indicate that the Dicksburg Hills, Merom, and other sandstones of their kind probably came from granitoid rocks and, apparently, were deposited as arkosic sandstones. It is believed that their soft or friable condition is largely caused by the presence of the intergranular kaolin. They are composed of imported materials brought in by a vigorous invading sea which overwhelmed and buried the indigenous beds of shales, thin coals, black sheety shales, and thin limestones occurring between them. Their places of origin as sediments are not known, but it is not improbable that they came from long distances, even from the old land mass of Llanoria, and it is very likely that they represent first-cycle deposits and were not derived from previously deposited beds.

The differences in the character and origin of the two types of sedimentary accumulation, described in the Dicksburg Hills region, form the basis upon which the upper Pennsylvanian beds of southwestern Indiana, and probably elsewhere, may be divided into successive formations, receive names, and be given definite status as stratigraphic units.

References

Collett, John, 1871, Geology of Sullivan County, 2nd Ann. Rept., Geol. Surv. of Ind., 191-240.

————, 1872, Geology of Pike County, 3rd and 4th Ann. Rept., Geol. Surv. of Ind., 239-287.

————, 1874, Geology of Knox County, 5th Ann. Rept., Geol. Surv. of Ind., 315-382. Geology of Gibson County, 5th Ann. Rept., Geol. Surv. of Ind., 383-422.

Collett, John, 1876, Geological Report on Vanderburgh County, 7th Ann. Rept., Geol. Surv. of Ind., 240-300.

————, 1884, Geology of Posey County, 13th Ann. Rept., Dept. Geol. and Nat. Hist., 45-70.

Cumings, E. R., 1922, Nomenclature and Description of the Geological Formations of Indiana, Pt. 4, Handbook of Indiana Geology, Publ. 21, Ind. Dept. Conservation, 403-570.

Fidlar, M. M., 1933, Some Hills of Circumalluviation in the Lower Wabash Valley, Proc. Ind. Acad. Sci., vol. 42, 135-140.

————, 1935, Alluviation in a Portion of the Lower Wabash Valley, Unpublished thesis, Dept. Geol., Ind. Univ., 106 pp.

————, 1936, Features of the Valley Floor of the Wabash River near Vincennes, Indiana, Proc. Ind. Acad. Sci., vol. 45, 175-182.

Fuller, M. L., and Ashley, G. H., 1902, Ditney Folio, no. 84, U. S. Geol. Surv., 8 pp.

Fuller, M. L., and Clapp, F. G., 1904, Patoka Folio, no. 105, U. S. Geol. Surv., 12 pp.

Lesquereux, Leo, 1862, Report on the Distribution of the Strata in the Coal Measures of Indiana, Ind. Geol. Surv., 269-341.

Logan, W. N., 1932, Geological Map of Indiana, Ind. Dept. of Conservation, Publ. 112.

Malott, C. A., 1939, The Hazelton Bridge Formation of the Upper Pennsylvanian of Southwestern Indiana, Proc. Ind. Acad. Sci., vol. 48, 114.

Shrock, R. R., and Malott, C. A., 1929, Structural Features of West Franklin Formation of Southwestern Indiana, Amer. Assoc. Petr. Geol., vol. 13, 1301-1314.

Flood Control in Indiana

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The 84th General Assembly of the State of Indiana passed Enrolled Act No. 174, Senate, and it was approved March 7th, 1945. This Act created the Indiana Flood Control and Water Resources Commission. It was the outgrowth of a semiofficial commission appointed by Governor Schricker a year or two previous for the purpose of studying Indiana flood situations and to determine how the flood problem should be attacked.

The Indiana Flood Control and Water Resources Commission is a bi-partisan body whose members number nineteen and are appointed with staggered terms. From this body of nineteen men, the Governor names nine who are known as the Executive Committee. The Executive Committee organizes itself with a Chairman and Vice Chairman. Its Secretary is employed by the Commission with the approval of the Governor.

The present commissioners live in all parts of the State of Indiana. They are attorneys, engineers, business men—men of many professions and many commercial pursuits. They are therefore representative of the people in the state not only by localities but also by vocations and occupations.

In addition to the Secretary, the Commission employes a chief engineer and a staff of clerical and engineering personnel. The engineering staff at the present time includes an office engineer, investigation engineer, a field engineer, a geologist, a field survey party of six men, two secretaries, two computers and three draftsmen. The Commission also employs a consulting engineer.

Because of the limited area of the state which is covered by U.S.G.S. topographic mapping, the Commission has purchased aerial photos to cover the entire state and index maps for all the counties.

Authority

The Indiana Flood Control & Water Resources Commission was given rather wide authority by the Indiana legislature. It is given authority over all public and private waters, both surface and underground. The Commission is charged with the responsibility of preparing for the state a master plan for flod control and water resources. It is given the authority to regulate all kinds of building in the floodway of Indiana streams where flood planning may be affected. No dam can be built in any stream without the Commission's approval in regard to its interfering with flood planning. It is not possible for power companies to construct plant sites on the valley floor of any stream without clearance from the Flood Commission. Individuals may be stopped from building homes or buildings of any kind in the Flood zones. Cities or industries or individuals may be prevented from encroaching upon the

channels of streams by filling in over the banks. The Powers of the Flood Commission will permit it to set up a system for regulating the construction of bridges by various government departments, by railroads, and others.

In the 85th General Assembly, which was concluded only a few months ago, an act known as the "Conservancy Act" was passed, which makes it possible for areas in the state, no matter how small as long as they are not entirely enclosed in any city or town corporate limits, to form a conservancy district for the purposes of solving any water problem or a combination of several water problems. The conservancy district must provide an official plan which is approved by a conservancy court set up by this act. For the execution of this official plan, the conservancy district may raise funds by assessment of lands in the district and may issue bonds in order to defray the cost of construction. The Indiana Flood Control & Water Resources Commission is given the responsibility of passing on the official plans of such conservancy districts. The purpose of this act was to make it possible for areas in the state to raise local funds for the purpose of cooperating with the U. S. Corps of Engineers in the construction of work for flood control, water supply, sanitation, recreation and for other purposes. This act was patterned after an act passed by the State of Ohio many years ago, under which the Miami Conservancy District and the Muskingum Conservancy District were created and their works constructed and presently operated.

The Commission has all authority to enter into and over any property in the state for the purpose of flood control surveys and for other purposes related thereto. It has a prior right of eminent domain and can condemn property for the purposes of flood control as it finds it necessary.

The Commission has had numerous occasions on which to exercise its authority and it has chosen to bring about the right kind of relationship with the public by using more persuasion than force. Difficulties arise in connection with levee districts and other flood works, which the Commission arbitrates or otherwise settles with little difficulty. It has been called upon to approve the plans of a power company which is now building a new $10,000,000 power plant on the valley floor of White River within thirty miles of Indianapolis. Another such case is pending. There are many cases throughout the state of encroachment upon the channels by industries and by city dumps. These encroachments must be dealt with. It is encroachment of this kind that has gone on in the past which is responsible in part for our present dilemma. I am confident, too, that a great deal of retardation is being incurred in the streams by the building of bridges which are inadequate insofar as floodway is concerned. We are working on several new cases of this kind at this time.

Indiana's Program

When I first came with the Commission, I was accosted by a gentleman who is in charge of an office in the same building with us, on the grounds that flood control planning is all unnecessary if we do the thing which should be done, in his estimation, namely, to move out of the floodways all industries, dwellings and developments which had no

business being built there in the first place. The farther I go with flood planning, the more I am convinced that there is a great deal of validity in his contention. However, we do not expect to move cities, people, industries and certainly not farms and the farmers, out of the river valleys bodily. That this is a difficult method of dealing with floods is shown by several instances. One community in Indiana, Leavenworth on the Ohio River, the Red Cross rehabilitated after the 1937 flood by moving it out onto the bluffs overlooking the Ohio River. Last week I went down into the old town of Leavenworth and was not surprised to find a dozen or more families living in the same old houses, which were completely covered by the 1937 flood,—some of the houses even shifted on their foundations and are scarcely safe for habitation. It would be nearly impossible to effect flood control by this method. In fact, such a method is not flood control, but flood escape.

After long and repeated discussions, the Indiana Flood Control and Water Resources commission has come to the conclusion that its remedial measures for floods must fall into four categories. In the first place, we believe that it is important for us to encourage the retardation of runoff on the land. This means the widespread use of soil conservation and reforestation practices. It may mean improvement in land use, proper rotations and good cover rather than terracing, sodded waterways and strip cropping. Certainly it will require all of these practices where they are applicable, and reforestation to an extent not yet considered by any of our governments—county, state or federal. At the present moment it seems that anything like comprehensive treatment of the lands in the midwest by such practices is a little remote, although we must admit that the Soil Conservation Service and the Forest Service have been making considerable strides toward the goal. In Indiana we feel that the programs of the soil conservation districts, forest purchase and Triple "A" subsidies offer the best opportunity to get this job done. In its present move for economy, Congress may eliminate parts of these programs, in which case the job must be done with what is left. It may not offer too much hope for the immediate future, but the Indiana Flood Control and Water Resources Commission feels that it must encourage these programs in the hope of effecting as much retardation of runoff as is possible.

The second method which we feel is due to play a large part in the control of floods, upstream and down, is the detention of runoff in some of the stream valleys by means of dams and reservoirs. The U. S. Corps of Engineers has had a comprehensive plan in mind for the midwest for a number of years which was to include many reservoirs, some of them quite large. Two of these reservoirs were recommended by the District Office at Louisville in its Wabash Basin report. In the federal plan they are fine and, personally, I have no doubt that they are needed downstream. However, there was considerable local opposition to these two projects and they were finally deleted from the plans by the National Board of Review and the Chief of Engineers. Our Commission feels that, for Indiana's sake, we need smaller reservoirs farther upstream. We realize that the cost of such smaller reservoirs per acre-foot of storage

is likely to be much greater, but we feel also that being farther upstream they will furnish more flood benefits to stream valleys throughout Indiana. This does not gainsay the fact that some day the system of large reservoirs, which has been planned by the Army Engineers, will need to be constructed. The third method for flood control which our Commission believes is necessary is local protective works. This means levees and flood walls. We do have a number of levees in Indiana at the present time. We have fully a score of such systems already in existence, many of them improved by the Army Engineers in recent years. There are nearly a score of levee systems which are on the approved list of the Chief's office at the present time. Indiana has no large levees such as are found farther down the Mississippi system, but it does have a number of smaller systems which are very important to the agriculture of the state. Furthermore, we have about a dozen cities along the major rivers of the state which are so situated as to require protection by levees and flood walls. We have complete protection for a few of those cities at the present time. The Corps of Engineers have plans for the protection of several more. There are some for which the planning yet must be done.

The fourth and final method of flood control which we find necessary is channel improvement. We feel that this method can be overdone very quickly and that it should be used in moderation. However, there are times and places in flood planning when it is necessary to open up bottlenecks and to cut off oxbows along with the use of other methods for flood protection. Our Commission hears daily from small cities and towns and from the farmers about flood control needs which often turn out to be only needs for dredging and straightening smaller streams in order to get the water away more quickly from points where a great deal of damage may be done. We have no way on the state level to deal with these problems. Such projects must still be done by the local people under drainage proceedings.

It is the very firm conviction of the Commission and its engineers that no one of these methods for flood control can be expected to do the job alone. There is scarcely any local flood problem where the combination of two or more of these methods is not required. Certainly we need to practice retardation on the land throughout the entire state as a general thing. To this in many places, we can add enough detention in the stream valleys to make it possible to lessen the height and cross-section of levees needed in local protective works. In any of these projects a little channel improvement is very likely to be required.

Insofar as reservoirs are concerned we hope that, wherever possible flood control reservoirs may be made multiple-purpose reservoirs. There are some cases where we are recommending reservoirs without conservation pools, where we feel that the flood control needs require all of the storage or where the type of site is not conducive to recreational development or where the reservoir may be situated close to an existing state park area, thus making recreational development at the point in question undesirable. We are trying in all cases to recommend upstream reservoirs where there are definite water-supply needs in order that water-supply features may be included with the flood control works. We have

in mind also the need for some low-flow control in certain streams where pollution is a menace. We have not considered, and probably will not consider, power development in any of the reservoirs which the state has recommended.

We feel that we have a very satisfactory understanding and relationship with the U. S. Corps of Engineers. Our work brings us into closer contact with the Louisville district and its personnel than any other district. They have been encouraging and helpful in our planning. It is understood between us that we are to make preliminary investigations throughout the state and recommend to the Army Engineers the procedure which the State of Indiana would like to follow. In keeping with this understanding, we have a field crew at work on preliminary surveys of reservoir sites. We have completed surveys on four reservoir sites in the tributaries of the Upper East Fork of White River. We are completing a report now on three reservoirs in the Muscatatuck tributaries of White River. Our field crews have finished surveys on fifteen tributaries of the Upper Wabash where reservoir sites are to be considered. We have gone over the matter of criteria with the Army Engineers and have come to understand the limitations put upon them by Congress. We do not ask them to consider any project which we do not find economically justifiable in our preliminary study. We are providing them with all of the field data on surveys as the reports are completed, in order that they may have information on all of these sites considered even though it be negative in some cases.

For several years the Corps of Engineers has been developing projects for flood control in Indiana and some of these are now completed and some under construction. The Commission works closely with the Corps of Engineers on these projects. They are local protective works at Indianapolis, Muncie, Vincennes, Cannelton, Evansville, Tell City, Jeffersonville, New Albany, Aurora and Lawrenceburg and a storage reservoir at Cagles Mill on Mill Creek in Putnam County.

We have very great hopes that some of our local areas with flood control water supply, pollution, and recreational problems may take advantage of the new law recently passed by the legislature by establishing themselves in conservancy districts. This would allow them to do a little local planning. Our Flood Commission is trying to see the problems from a local viewpoint, but we have some of the same difficulties in seeing the local problem that the federal agencies have in seeing the state problems. In addition to the advantages of local planning, we believe that much of the expense of construction of works, for water supply and recreation particularly, should be borne by the people who benefit most directly from it. Two or three areas already are taking steps to form conservancy districts.

Conclusions

The Indiana Flood Control and Water Resources Commission realizes that it probably never will control floods in Indiana completely. There are those in all walks of life who are perfectionists who approach problems with the hope of complete solution. But we can not work with the

solution of these problems for the public without realizing that a great many limitations are put upon us which make it nearly impossible to reach a one hundred percent solution. If we had all of the money that we needed to spend and all the personnel we needed to do the job and on top of this the agreement of everybody to allow duly constituted authorities to make the decisions, we might expect to gain complete control of floods.

But I am not sure that this would be a desirable thing if we could do it. Certainly we must stay within the bounds of economic justification. We can do a great deal of good toward the solution of flood control problems by discouraging further building in the flood plains. We must try always to disseminate correct information in order that the public may be as correctly informed as possible. We are inclined to believe that the states must do the job for themselves insofar as that is possible. But we know that it will leave much to be done by agencies of the federal government.

The federal agencies must first correlate their own efforts and then assist in the correlation of state efforts. We believe firmly that local cooperation on flood projects should be emphasized to a greater degree in the future.

An Example of Lapiés in the Indiana Karst Region

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The purpose of this paper is to describe a small area of lapiés in central Lawrence County, Indiana, and to discuss some of the aspects of its origin as a feature typically present but rarely exposed in the Indiana karst region. The area was first pointed out to the writer by Dr. C. A. Malott in 1940. It was specifically mentioned by him as an excellent example of a species of karst feature in his comprehensive paper on karst forms in southern Indiana published in 1945. The present paper has resulted from a detailed study of this interesting example of a special karst surface, previously given but scant attention in Indiana karst studies, and has benefited from criticism offered by Dr. Malott, who read the original manuscript. The writer gratefully acknowledges his indebtedness.

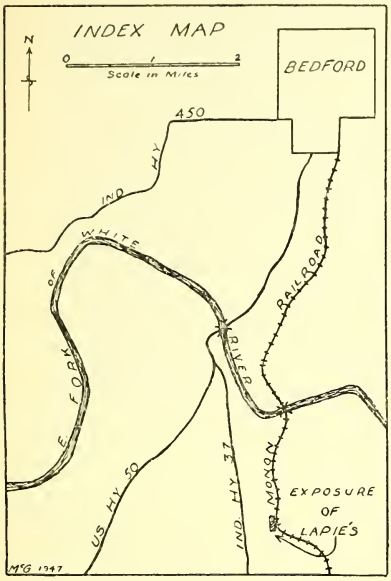
Lapiés may be described as rugged, irregular, furrowed, grooved, fretted, etched, pitted, and otherwise dissolved surfaces of exposed limestone. It is best developed in pure, massive, jointed limestone. However, features similar to lapiés have been described in other rocks.

Acording to Cvijic (1924) it was as far back as 1893 that appreciation of the association of lapiés proper with limestone led to the classification of lapiés as a karst form. He said that lapiés were first observed and described in the limestone Alps in Switzerland where in the customs of German speech they were called *Karren* or *Schratten* and in the districts of French speech *lapiéz* or *lapiaz* or *lapiés*. The British, according to Wray (1922), North (1930), and Woolridge and Morgan (1937), have used the term *clint* to refer to such features. (It should be noted that the British term *clint* should not be confused with *klint*—any remnant of the unreduced portion of an ancient organic reef.) Wray (1922) also wrote that in Switzerland these barren limestone surfaces are known as *Karrenfelder*, and the grooved and trenched limestone pavements in the Jura Mountains are called *lezinnes*.

Opportunities to view exposed upper surfaces of the etched and weathered limestone beds are often quite limited in areas of low relief and humid climate. The deep cover of red, residual clay literally blankets the limestone belt of Indiana and other limestone areas in humid climates. The thickness of this blanket varies of course, and has been found from nothing to many feet. At a drill test on an upland near the village of Dogwood, Harrison County, Indiana, in 1946, the writer logged almost 60 feet of residuum before bedrock was encountered. Because of this residual mantle, good examples of natural exposures of limestone surfaces are relatively rare, and recourse must be sought in man-made excavations in order to view the detailed characteristics of the etched and weathered upper surfaces of limestone areas. In his well illustrated

article Cumings (1905) has presented excellent views of some artificially exposed corroded limestone surfaces, particularly in the Monroe County, Indiana, limestone quarry district.

The area described below is located adjacent to the Monon Railroad in Section 10, Township 4 North, Range 1 West, about one-third of a mile east of Indiana Highway 37, some 3½ miles south of Bedford (Fig. 1).



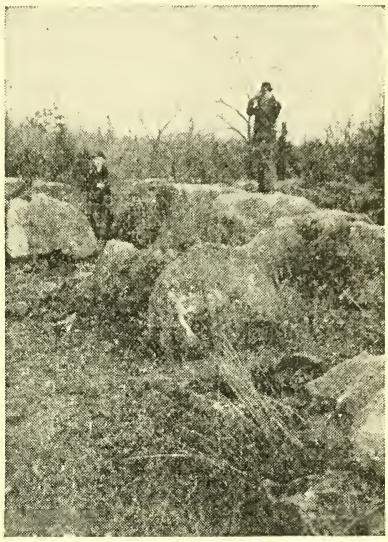


Fig. 1. Sketch map of portion of Lawrence County, Indiana, showing location of area studied.

Fig. 2. View of lapiés area showing the irregular rock surface.

The soil blanket at this locality is thin, but the rocks in the main area were exposed by removal of the soil cover, probably to make the adjacent railroad fill in 1849 or 1850. After much of the surface soil was removed artificially, rainwash and off-flowing waters have removed much of the remainder of the residual clay and small rock particles which filled joints, cracks, and other openings and revealed a ragged, irregular rock surface with local relief from a few inches to six feet or more (Fig. 2). To this surface Malott (1945) applied the term lapiés, and in view of this and the fact that the term lapiés has been adopted by many of the text books, such as Lobeck (1939), Cotton (1942), and von Engeln (1942), the writer wishes to retain the French rather than British, German, or Serbian term for this and similar features of karst expression.

The area studied was over 500 feet long and 200 feet wide, comprising about 2½ acres. Only a portion of the lapiés area is represented by the

accompanying sketch map (Fig. 3). The exposed rocks are all Salem limestone. The Salem here is generally massive, jointed, coarse, fossiliferous and oölitic limestone with little show of bedding. The residual material lying between and around the bedrock exposures is a deep, red clay, tough and sticky when wet, with occasional silicified fossils and chert fragments, commonly referred to as *terra rosa*. The most striking feature of the area is the ridge-like elongation of the outcrops which tend to align themselves in a general east-west direction which parallels a well-developed joint system in the dip direction of the rock formations. (It is interesting to note that this same phenomenon has been observed in

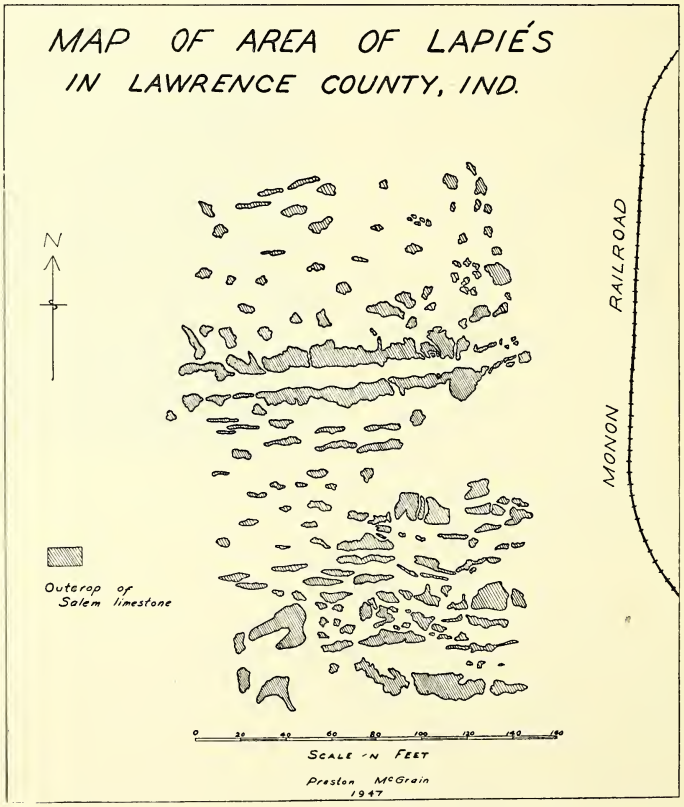


Fig. 3. Sketch map of portion of lapiés area near Bedford, Indiana. The ridges of Salem limestone are in general parallel to a well developed joint system in the dip direction of the rock formations.

numerous Salem limestone quarries.) One looks in vain for any alignment of the etched-out remnants in a north-south direction, and little or no suggestion is found of a joint development in a north-south or strike direction. The largest feature in the area is a wide, clay-filled joint which

extends almost the full width of the area (Fig. 4). It is 5 to 9 feet wide and the floor is 6 feet or more below the highest limestone ridges which form the sides. The British term for solution joints is *grykes* or *grikes* while the Serbians have used the word *bogaz* for the deeper fissures. According to official British sources, *bogaz* is used for the more trench-like

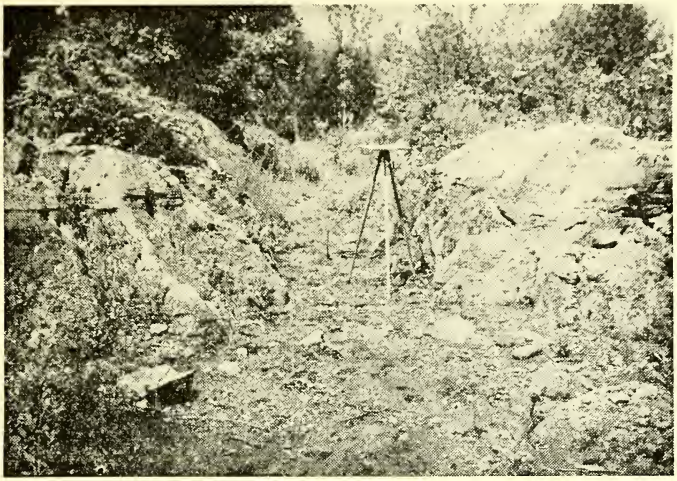


Fig. 4. View of bogaz or grike. At this point the rock walls are 6 feet above the clay floor.

fissures, sometimes quite shallow in depth, but of considerable length though narrow in cross-section. The surfaces of the individual ridges, mounds, and hummocks have been sculptured in a variety of ways (Fig. 5). Many are rounded and are massive appearing. Some are fluted; on

Fig. 5. View of the sculptured surface of one of the limestone ridges.

others small fractures appear to be responsible for the development of a network of small trenches separated by sharp ridges and pinnacles. Such a terrain is difficult to cross.

The strikingly rugged surfaces of lapiés have attracted attention wherever they have been viewed, but some important aspects of the development have not been clearly set-forth. Cvijic (1924), in his classical paper on lapiés, emphasized that the origin and development of this karst form were dependent upon the limestone surface being laid bare. He contended that lapiés are much more extensive where the surface is not covered, but he did recognize that the features of lapiés could develop beneath a cover of dead vegetation or soil residuum. The lapiés described herein was fully developed beneath a soil cover. The soil cover was excavated to the top of the bedrock surface and the clay filling in the joints and cracks was removed by the corrasive action of rain wash. This process is continuing at the present, deepening the *bogaz* or *grikes* and revealing other limestone surfaces. Thus the origin of the lapiés is due to the dissolving effects of meteoric waters charged with carbon dioxide which percolate through the residual mantle and reach the underlying rock. Here the descending waters are concentrated along preestablished joints and other fractures and grooves, enlarging them many times, and forming the other individual features which characterize the lapiés surfaces of limestone areas. Hence, it is believed that lapiés features are commonly developed beneath a soil cover and are of widespread occurrence in limestone areas, though hidden under the soil mantle. When the soil is removed they become conspicuous and attract attention. When once uncovered they are subject to surface weathering and modification. It is possible in areas of low relief that lapiés features developed beneath the surface and then exposed may be so modified in time that they will become inconspicuous or even largely destroyed.

References

Cotton, C. A. (1942) *Geomorphology: an introduction to the study of landforms,* Whitecombe & Tombs Ltd., Wellington, New Zealand.

Cumings, E. R. (1906) *Weathering of the Subcarboniferous limestones of southern Indiana,* Ind. Acad. Sci., Proc. 1905, p. 85-100.

Cvijic, Jovan (1924) *The evolution of lapies, a study in karst physiography,* Geog. Review, vol. 14, p. 28-48.

von Engeln, O. D. (1942) *Geomorphology: systematic and regional,* The Macmillan Co., New York.

Lobeck, A. K. (1939) *Geomorphology: an introduction to the study of landscapes,* McGraw-Hill Book Co., New York.

Malott, C. A. (1945) *Significant features of the Indiana karst,* Ind. Acad. Sci., Proc. 1944, p. 8-24.

North, F. J. (1930) *Limestones, their origins, distribution, and uses,* Thomas Murby & Co., London.

Wooldridge, S. W. and Morgan, R. S. (1937) *The physical basis of geography: an outline of geomorphology,* Longmans, Greene & Co., New York.

Wray, D. A. (1922) *Karstlands of Western Yugoslavia,* Geol. Mag., vol. 59, p. 394-409.

A Stepping-Type Wind Speed Maximeter Using Standard Parts

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Introduction

During the latter part of the recent war, in response to an immediate need for an instrument that would indicate, record, or transmit the maximum wind travel during any one minute of a longer reporting interval (such as one hour), extensive experiments were conducted, and several workable instruments were designed and constructed. These devices, described elsewhere[1], having been built under "war rush" conditions, on a "cost immaterial" basis, are not suitable, in their original form, for ordinary station or laboratory use, because of high first cost, short service life, and excessive maintenance needs.

Further study of the problem has resulted in the development of a design for an instrument to indicate, record, or transmit "hourly one-minute wind-speed maxima", composed entirely of standard parts, to be reported here; and of an instrument for indicating, recording, or transmitting longer-term wind-speed maxima (such as monthly one-hour), to be reported separately at a later date.

Basic Principles

The stepping-type maximeter consists, in brief, of a telephone-type stepping switch, which, starting from zero at zero time, is "stepped up" one contact for each wind travel increment until reset to zero by the clock. The position of the contact arm of the switch immediately before resetting to zero at the end of the time interval corresponds to the number of wind travel increments received during that time interval.

Electrically coupled to this first stepping switch is another of identical electromechanical design, so connected to the first that, when both switches start from zero, the second switch steps up one contact each time the first switch is stepped up by a wind travel increment. However, when the first switch is reset by the clock, the second is not. In consequence, at the end of the first time interval, if the first switch stepped to its Nth contact before resetting, the second switch, after the first is reset, remains on its Nth contact. Thereafter, the second switch remains on its Nth contact until the first steps to its N+1th contact. When this occurs, the second switch steps to the N+1th contact and retains that position. As a result, the position retained by the second switch is the maximum attained by the first switch during the time interval under consideration. (Further details of the follower mechanism are given in Figure 4, and in the technical description of the followers).

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[1] Ives, R. L. *Experimental Maximeters for Wind Speed,* Bull. Amer. Met. Soc, Vol. 27, 1946, 224-229.

Arrangement of Components

Arrangement of components of this maximeter is shown in Figure 1, a block diagram in which the major operating connections are indicated. Although the decaders, followers, and interlocks are complexly interconnected, and must be placed close together, the other components are relatively simple, both electrically and mechanically, and may be placed where convenient.

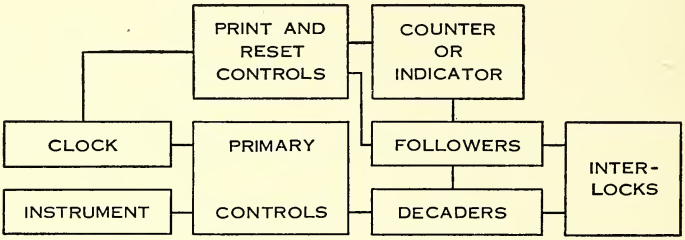

Fig. 1. Block diagram showing arrangement of components of maximeter.

Construction and Function of Components

Introduction. Each major component of this maximeter has a definite and specific function. To reduce the complexity of the circuit diagrams, each circuit is shown with its own battery. In practice, the number of batteries, or D.C. power supplies, is considerably less, and the entire device can be operated from a single power supply of sufficient capacity. Where all components work from a single supply, however, care must be taken to prevent circuit interlocks, power surges, and resultant conflicts of functions.

Instrument. The instrument for which this maximeter is designed is any contacting anemometer of conventional design, such as the Signal Corps ML-80 anemometer, which is a Robinson three-cup instrument, with one-sixtieth mile contacts.

The instrument supplies the wind travel increments (contact closures) from which the maximeter operates. By use of a modified contacting gear, contact intervals other than one-sixtieth mile are obtainable. For special purposes, an electrical submultiplier[2] may be used in conjunction with the anemometer contacts.

Clocks. The clock used with this maximeter is any convenient contacting clock, such as the Struthers-Dunn "Repeating Timer". Two contacting intervals are necessary—one for the measuring period (such as one minute) and one for the recording period (such as one hour). Where line power is available, an electric clock movement is convenient.

The clock supplies the time impulses which determine the measuring and reporting periods. These may be altered, within reasonable limits, by proper choice of gearing and contacting mechanisms.

[2] Ives, R. L. *Submultiple Anemometer Contactors,* Bull. Amer. Met. Soc. Vol. 27, 1946, 346-347.

Primary Controls. The primary controls couple the instrument and clock to the decaders, and are designed to reduce the possibility of conflicts between instrument and clock signals.

Connections of instrument, clock, and primary controls are shown in Figure 2. The anemometer circuit, consisting of battery A and relay

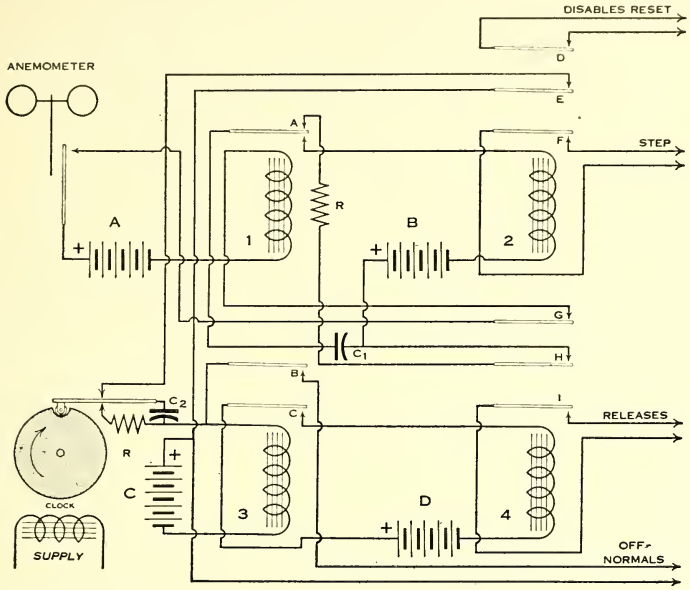

Fig. 2. Circuit of primary controls.

1 may include a long line (up to several miles) from the anemometer tower to the instrument location. Battery voltage, obviously, must be sufficient to compensate for line drop. If desired, an A.C. relay may be used in this circuit, with an alternating current line supply.

Controlled by the anemometer circuit is a limiter circuit, consisting of battery B, relay 2, and condenser C_1. When the anemometer contacts close, the armature of relay 1 pulls down, connecting relay 2, battery B, and condenser C_1 in series. Relay 2 now closes, but remains closed only as long as the charging current of C_1 exceeds the drop out current of the relay. When the current falls below this critical value, relay 2 opens, and remains open, no matter how long the anemometer contacts remain closed[3]. This protects the stepping circuit of the decader, controlled by contacts F of relay 2, from overheating should the anemometer "stall" with its contacts closed, a not infrequent occurrence.

[3] Details and constants of the relay—condenser limiter are fully described in Ives, R. L. *The Relay Oscillator and Related Devices,* Jour. Franklin Institute, Vol. 242, 1946, 243-279; and in Army Report (classified) DPGSR 63, 1946, OC-CWS 5063-63.

When the anemometer contacts open, relay 1 is deenergised, its armature rises, and condenser C_1 is discharged through protective resistor R.

The contact closures which determine the measuring period are produced by the clock, through a limiter circuit consisting of relay 3, battery C, and condenser C_2. Incorporated in this limiter circuit is a "lock in" circuit (contacts B, relay 3), so arranged that the release circuit of the decader is continually energised until all off-normal contacts (in the decader) have opened, but no longer, regardless of the duration of the clock contact closure. This prevents conflict or duplication of release functions, and makes unnecessary a critical adjustment of the clock contacts.

Controlled by the clock limiter (relay 3) is a power relay (4), which energises the release circuits in the decader. One contact on this relay is required for each stepping switch in the decader, and these contacts must be of ample capacity for the relatively large currents drawn. If desired, the local circuit, consisting of relay 4, battery D, and contacts C of relay 3, can be modified for alternating current operation at any desired voltage (within reason).

To prevent overlapping of the control impulses from the clock and anemometer requires protective equipment of impracticable complexity. The number of such overlaps and conflicts, however, can be reduced to a negligible value (such as one per 1,000,000 operations) by use of relatively simple interlock circuits.

Whenever the release circuit (contacts I, relay 4, Fig. 2) is closed, the stepping circuit is disabled by opening of contacts G (relay 4). To prevent a dual stepping impulse when a clock contact closure occurs soon after an anemometer contact closure, discharge of C_1, during a reset period, is prevented by opening of contacts H (relay 4). Conflict of release and anemometer functions is still further reduced by disablement of the clock limiter, during stepping intervals, by opening of contacts E (relay 2). The printer is also kept out of operation during stepping intervals by a disabler (contacts D, relay 2).

A number of alternative interlock circuits are possible. Use of more complicated protective devices is entirely possible, but a condition of "overinsurance", in which more records are lost by failure of the protective devices than would be lost were the protective devices simpler or absent, must be guarded against.

Decaders. In the original maximeter design, the stepping equipment consisted of two 100-point stepping switches in cascade, so that, when the first had stepped upward to its limit (100 points), the second was connected in circuit, and recorded all incoming impulses from 101 to 200. This system, which also required sixteen auxiliary relays, suffered from high first cost, high maintenance cost, and required a major overhaul every few thousand miles (of wind).

Equipment performing the same electrical functions, but consisting of three ten-point stepping switches and only two auxiliary relays,

is shown in Figure 3. With this arrangement, the DECADER of Figure 1, the first stepping switch (UNITS, Fig. 3) is advanced one contact for each incoming anemometer contact closure, these closures being of very short duration, because of the action of the limiter (in PRIMARY CONTROLS, Fig. 2).

When the first stepping switch reaches the tenth position, relay 1 (Fig. 3) is energised through the switch arm and contact 10, and closes. This locks in place, through contacts A, and energises both the release

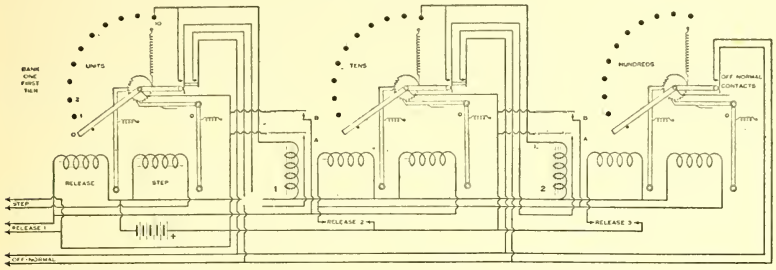

Fig. 3. Wiring diagram of decader.

coil of the Units stepping switch, and the step coil of the Tens stepping switch. This steps the Tens switch from zero position to contact 1, and releases the Units switch, permitting its arm to return to zero position. When this occurs, the off-normal contacts, controlled by the switch arm, open, relay 1 is released by the opening of its lock-in circuit (contacts A), and the Units switch is ready for the 11th impulse, which advances the arm from zero position to contact 1.

An identical sequence of events takes place when the Tens switch arm reaches the tenth contact. The Tens switch is reset to zero, and the hundreds switch is advanced from zero to contact 1. This system can be extended to accommodate any number of incoming impulses, one stepping switch and one relay being required for each power of ten concerned.

At the end of the measuring interval (one minute in this case), the clock, through the limiter circuit in the PRIMARY CONTROLS, closes all the release circuits (Release 1, Release 2, etc., Fig. 3) so that the release coil of each stepping switch is energised from the battery (Fig. 3). The ratchet of each stepping switch is thus released, and each switch arm, actuated by its own return spring, returns to zero position.

As each switch arm reaches zero position, the off-normal contacts controlled by it are opened. The off-normal contacts of all three switches are connected in parallel, and to the "Off Normal" line, which is in series with the lock-in circuit (Fig. 2). When all three off-normal contacts are open, and only then, the lock-in circuit is opened, and the release circuits are deenergised. The decader is then ready for further incoming impulses. The releasing sequence takes place in 0.05 sec. or less, depend-

ing upon the tension of the return springs in the stepping switches and related factors.

Immediately prior to reset, the positions of the arms of the decader stepping switches indicate the total number of wind travel impulses during the previous measuring period (minute).

Followers. To retain a record of the maximum count attained during any single measuring period (minute) until the end of a recording period (hour), each stepping switch in the decader is connected to a similar switch wired as a follower. Electrical operation is accomplished by wiring each contact of the second bank in the decader switches to the N-1th contact in the first bank of the corresponding follower switch. Electrical details of these connections are shown for one pair of switches in Figure 4. A relay shunted across the release coil of the follower

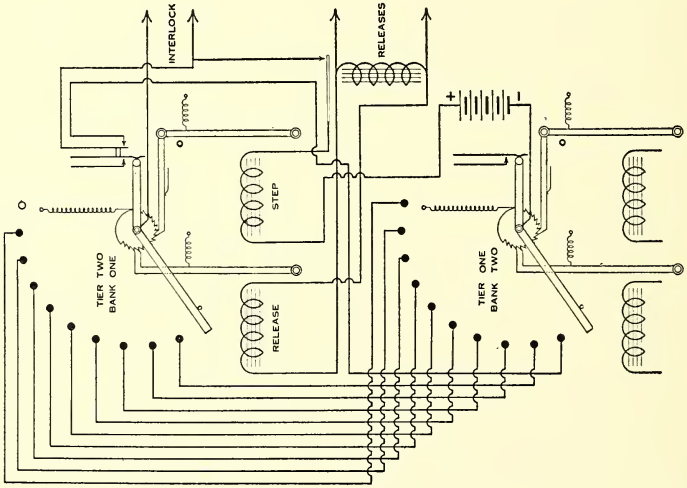

Fig. 4. Electrical connections of follower mechanism.

disables the stepping coil during the time that the switch is resetting to zero, thereby preventing circuit conflicts, with resultant "grabbing" and stripping of the stepping ratchet. The release coil of the units switch in the follower is connected across the step coil of the tens switch in the follower through an interlock (Fig. 5). An identical interconnection of the tens and hundreds followers is made. In practice, both interlocks can be controlled by the same relay, which may be a component of the print and reset unit, also performing other switching functions.

When the interlock terminals in Fig. 4 are shorted, the follower will immediately step up, in response to an increment in the count of the units switch in the decader, to any position; but when it reaches the tenth contact, it remains there, while the decader units switch returns to zero. The follower units switch is returned to zero only when the decader tens switch steps up one position.

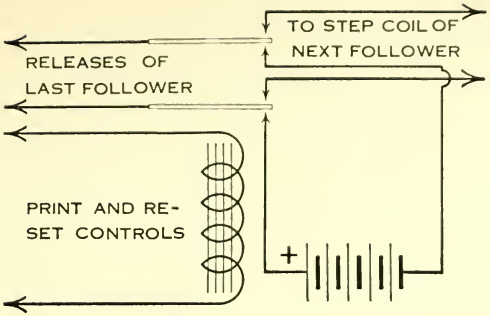

Fig. 5. Follower release interlock circuit.

An electrically and mechanically identical arrangement of switches coupled to the tens and hundreds switches of the decader enables the follower to attain and retain any position reached by the contact arms of the decader switches.

Interlocks. The purpose of the major interlocks between the decaders and the followers (Fig. 1, 3, 4 and 6) is to keep the two systems in phase. Without the interlocks, the units follower, if on position 5 (for example) would step to position 6, in response to an increment in the units switch of the decader, regardless of the positions of the tens and hundreds followers with respect to their respective decaders. By interconnecting the decaders and followers of the tens and hundreds components, so that the units follower will not step in response to a units decader increment unless the increment is an actual increase over the previously-recorded maximum, the total count of the followers becomes a true maximum.

Interlock connections for the units follower are shown in Fig. 6. It will be noted that the units follower interlock circuit is closed only when the tens decader and follower are on like-numbered contacts; and when the hundreds decader and follower are likewise on like-numbered contacts.

Analogous connections are made in the hundreds circuit, using bank three of both decader and follower, to keep the tens circuits in phase with each other. There being no decades beyond the hundreds, the interlock connections (Fig. 4) of the hundreds decader and follower are short-circuited. It should be noted that one bank of contacts, on each switch, is needed for each power of ten concerned in a decaded system, unless subsidiary interlock relays are employed.

Counter or Indicator Connections. A counter or other indicator may be connected to the follower system in many ways, most of them obvious. Simplest connection is to shunt the counter across the units follower stepping coil. This will then indicate the maximum wind travel (per measuring period) since the system (counter and followers) was last reset.

Where counter operating voltage is not compatible with that of the units follower, the counter may be controlled by a relay shunted across the units follower stepping coil.

A slightly different arrangement, permitting close regulation of the counter timing cycle (desirable with high-speed and printing counters)

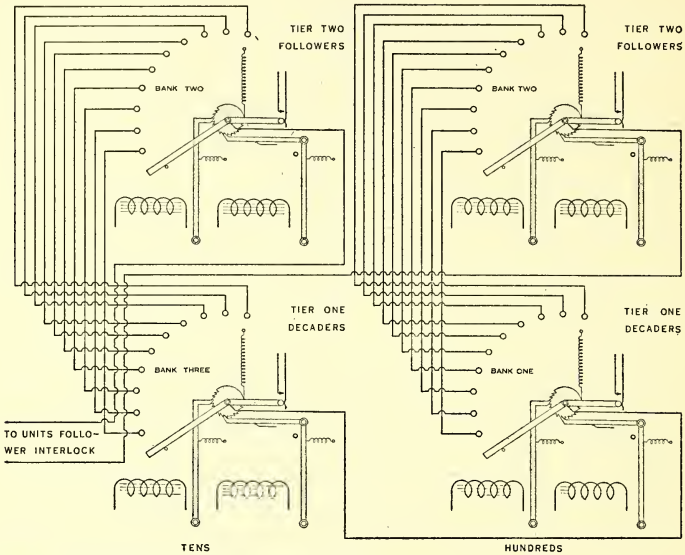

Fig. 6. Interlock circuit for units follower.

is shown in Figure 7. Here, a relay-condenser time limit circuit is operated by the second bank of contacts on the units follower stepping switch. When the switch arm moves from zero position to point 1, the condenser, battery, and counter control relay are connected in series. The

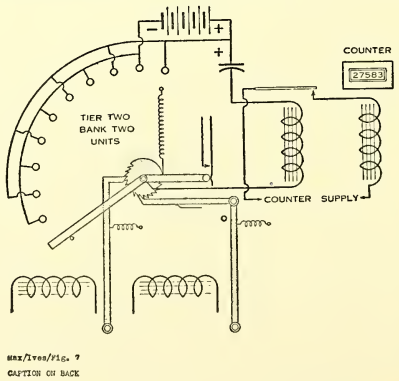

Fig. 7. Time-cycle control circuit for counter, operated by units follower.

relay closes immediately, but remains closed only so long as the charging current of the condenser exceeds the drop-out current of the relay. When this occurs, the relay opens, and will not close again, with this connection, until the condenser is discharged.

When the switch arm travels from point one to point two, the charged condenser is connected across the relay, which closes and remains closed until the discharging current falls below the drop-out value for the relay, which then opens and remains open. The condenser, however, continues to discharge through the relay coil, until its charge declines to substantially zero (see reference 3 for constants and details of operation).

Print and Reset Controls. When a printing counter is used, as is desirable in unattended or busy stations, it is operated, at the end of each reporting period, by a clock control, similar, except for contacting interval, to the clock shown in Fig. 2. Immediately after printing, the counter and the followers are reset to zero (this can be done automatically), and a new recording cycle begins. Exact circuit arrangement depends upon the construction and constants of the printing counter used, and is, in most instances, simple and obvious.

Operation

Operation of a maximeter of this type is entirely automatic, except for periodic replenishment of the recorder ink and paper, and systematic checking and maintenance.

Each anemometer contact closure causes a one-step increment in the count of the decader. When the units decade reaches top mark (10), the units switch automatically resets to zero, and in so doing steps the tens decade switch up one point. When the tens reaches top mark, it returns to zero, and steps the hundreds decade up one point.

The followers, acting in response to circuit completions in the decaders, increase their total count whenever the count of the decader exceeds the previous total count of the followers.

The decader is reset to zero at the end of each measuring period, but the followers are not. In consequence, the follower total is the maximum count attained since the last resetting by the decader. At the end of each recording period, the follower count, as recorded on a printing counter (or otherwise) is printed on a record tape, and the entire system is reset to zero.

If the measuring period is one minute, and the recording period is set at one hour, the resultant record consists of the one-minute wind speed maxima attained each hour. A wide variety of other measuring and recording intervals are possible, and relatively minor instrumental modifications make possible measurement of other maxima. If the decader alone is used, it is a convenient totalizing device for various data indicated by contact closures of irregular or random temporal arrangement (such as static or cosmic-ray "bursts").

Maintenance

Electro-mechanical equipment, in general, is fairly rugged, and will continue to function for a considerable time even under conditions

of total neglect. Electro-mechanical recording equipment, such as the maximeter here described, in which a number of functions are interdependent, will not retain its accuracy, even though it may appear to be working, unless skilfully and systematically maintained. Where standard telephone components are used, weekly cleaning of contacts, oiling of bearings, and testing of all functions, is indicated. Maintenance may be facilitated if the components are mounted so that all adjustments are easily accessible to the maintainer. Adjustments that can only be made by use of a bronchoscope are usually neglected.

Experience with pilot models of this type of maximeter indicates that testing is greatly facilitated if a jack is placed in each stepping circuit, so that each switch may be tested by plugging in a standard telephone dial. This permits checking of the switches individually, and of any part of the assembly, in a matter of minutes.

Conclusions

Redesign of this maximeter, so that standard telephone parts are used in place of expensive "made to order" components, has reduced first cost from slightly more than $800.00 exclusive of the counter, to about $220.00 (1947 prices). Sixteen fewer relays are needed in this newer design, and the number of replacement parts which should be kept in stock has been halved. Maintenance costs are markedly lower, as is the difficulty of maintenance work. It is probable that component life has been increased, although, because of the ending of hostilities, no maximeter of this specific design was used long enough to wear out.

Additional minor modifications, using nonstandard assemblies of standard components, suggest slight reductions in the number of fallible parts and contacts, but give no promise of marked reduction in either costs or maintenance needs.

Where it is necessary to record hourly one-minute wind speed maxima, or similar conditions, the design here outlined is superior in all respects to the original (reference 1). Minor modifications of this instrument, or of its major components, will be found useful in various recording, computing, and discriminating instruments for use in environments where either mechanical or vacuum tube devices are not suitable.

Accelerated Erosion Due to Industrial Waste*

GRANT T. WICKWIRE, Hanover College

Introduction

The stream studied in this report is Jenny Lind Run which empties into the Ohio River 13 miles above the city of Louisville, Ky. Source of the stream is 1¾ miles south of the town of Charlestown, Ind. The stream course is southerly for 1.8 miles, then turns abruptly east for 1.7 miles where it joins the Ohio.

The government owned powder plant located at Charlestown, Indiana, discharged the waste acid and water used in manufacture into Jenny Lind Run. Since the underlying rock is limestone, the result was a greatly accelerated erosion. It is the object of this report to describe this rapid Karst development.

Grateful acknowledgment is made to Lt. Col. John D. Armitage, Commanding Officer, Indiana Arsenal, for his generous cooperation and encouragement. Especial thanks are also offered Mr. Fred Woleben, Chief Civilian Administrator of the Arsenal, for access to his personal records. Without Mr. Woleben's generosity in giving of his time and intimate knowledge of the history of the Arsenal, this work could not have been done.

The Stream and Region Before Industrialization

Jenny Lind Run is shown as part of the Charlestown, Ind.-Ky. quadrangle published in 1937 by the U. S. Geological Survey. Jenny Lind Run empties into the Ohio River at 420 ft. above sea level when the river is at "normal pool stage." The lower 1.8 miles of the course were mapped as .permanent stream and the upper 1.7 intermittent. Throughout that part of the course mapped as permanent the Run is trenched more than 100 ft. below the general level of the upland; the intermittent portion drops abruptly from the gently rolling upland to this depth. The general level of the upland is 600 feet with gentle rises of 20 feet more or less above the general elevation.

Sinkholes are fairly numerous on the upland, the map showing 12 to 15 to the square mile. Sharp trenching of the streams, as already described for Jenny Lind Run, is characteristic.

Several caves were discovered in the course of preliminary surveying of the area. The longest that could be entered and mapped was less than a mile. In short, the region offers an example of Karst topography in the youthful stage.

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* No objection to publication on grounds of military security. War Department Public Relations Division. Review of material for military security does not imply War Department indorsement of factual accuracy or opinion.

Course Changes Preliminary to Industrial Use

Near the source of the Run a series of long narrow sinkholes extended northwestward. A channel was dug connecting these sinks, thus lengthening the surface course of the stream.

A dam was thrown across the Run 1½ miles above the mouth, impounding a lake about 500 yards long and over 20 feet deep. This lake was designed to serve as a settling basin for plant waste. The spillway of the dam was constructed so that water passing over it was vigorously aereated. The stream was bridged for highways and railroads at several points.

At the head of the artificially lengthened portion of the stream a second basin was also built. This basin received waste from some preliminary steps in manufacture. Its waters were not acidic.

The acid discharge tiles (A of map), sometimes referred to as the outfall of plant effluent, were near the mid-point of the artificially lengthened course and 2.8 miles above the mouth. The dug portion of the valley of the Run seems to have been clayfloored originally; a fact of some significance in this study.

History of Plant Operation

Although manufacture of nitric acid began in April 1941, there was considerable lag before waste began to reach Jenny Lind Run, so that the first acid reached the creek at the beginning of May. Production of powder and hence volume of waste water and of acid varied. There was also a seasonal variation in the amount of water used. The peak flow was reached in early July, 1942, and continued at a high level until August 20, 1945 when production was reduced to ⅙ capacity. Production ceased October 1, 1945. Thus there was a total operating period of 52 months.

Amount and Nature of Acid Waste

Not all water furnished the plant was discharged into the Run, nor were careful measurements made to determine the exact amount that did flow away as waste. Estimates however were furnished the writer, based on the way the plant was constructed and on some partial observations. The average flow was thus estimated at 22,500 gallons per minute with peak flow in late summer reaching 32,000 g.p.m.

When discarded the acid had an hydrogen-ion concentration (pH) of 2.3. Before being dumped into the Run, pulverized limestone was added, changing the pH to 3.2. These pH values remained essentially constant throughout the period of plant operation, according to report. The limestone dissolved from the bed of Jenny Lind Run completed the neutralization of the acids. That such was the case is proved by repeated tests near the mouth of the stream showing a pH of 6.8 to 7.0.

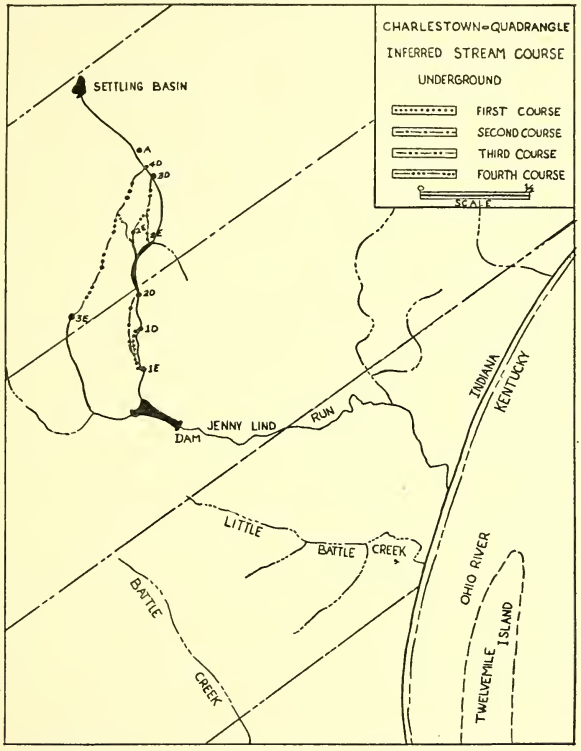
Temperature of water in the Run was about 80 degrees F. due to its use for cooling in certain of the industrial processes.

Stream Changes During Plant Operation

Unfortunately exact dates for stream changes are not available, since in some instances disappearance of the stream was not immediately

discovered. The early swallow-holes appeared in an inaccessible and seldom-visited area. Further, the date when swallow-holes were discovered does not seem to have been recorded in the plant files; at least such could not be found. Approximate dates are available, however since undermining of certain plant routes necessitated changes in operation.

The accompanying diagram show the series of major changes that occurred. One large additional cavern was noted by the writer in his exploration of the stream, but whether this opening was one of emergence or disappearance there seemed to be no way of determining.



The diagram shows the first major change discovered. It occurred in the fall of 1942, probably October. The distance between the swallow-hole (1D) and spring (1E) is 1750 feet as one follows the twists and bends of the channel. The portion of the bed of the stream deserted at this time was not again occupied by plant effluent, so measurements here give an indication of the amount of solution taking place from May 1941 to October 1942—seventeen months. 1D marks point of disappearance, 1E point of emergence, and A the position of out-fall acid effluent. The sides of the stream course were carefully studied to determine the level of the stream before acid attack; and wherever such determination was possible, calculations were made of bedrock removed by factory

waste. A series of measurements taken from 15 to 50 feet above the spring (emergent point 1E), in the abandoned portion of the stream bed showed average erosion of 7 feet 6 inches by 8 feet 6 inches width. Approximately midway of the abandoned section several measurements average 8 feet 1 inch depth by 7 feet 2 inches width. Fifty feet downstream from the swallow-hole, (point of disappearance 1D), acid waste had trenched the bedrock 5 feet 6 inches in depth by 7 feet 5 inches in width.

The conditions shown held for six months, when a new swallow-hole appeared 1000 feet upstream.[1] The stream abandoned a total of 2,750 feet of its original course. Trenching of the limestone downstream from this second swallow-hole (2D on map) was not great. It varied from 2½ feet to 3½ feet depth by 10 feet 6 inches to 10 feet 9 inches width.

Upstream from swallow-hole 2D, trenching was deep; the first exposures show limestone cut 7 feet four inches depth by 8 feet 2 inches width. One hundred and fifty feet above the swallow hole a concrete-floor culvert below a highway shows 6 feet of concrete and limestone removed. This strikingly deep and narrow trenching of limestone is to be expected for this part of the course, since it was occupied longer than any other stretch of valley—thirty-eight months.

In May 1943 a new swallow-hole (3D) appeared, a mere 2 months after 2D just described. This new opening was ¾ mile up valley from 2D and only 800 feet below the outfall of plant effluent (A). It was also but a few yards below a vitrified tile culvert beneath one of the plant railroads. This new disappearance of the stream was the first to produce a marked change in the general pattern of the Run. The stream disappearing at 3D reappeared mostly at 2E and 2E1 but some water also worked to the surface as seepage, making a swampy area between the two points, killing trees ad similar upland vegetation.

From the present aspect, 2E[1], the westernmost opening, carried the most water. This opening is a small cave that existed before the acid waters were thrown into the area.

The stream now had its most complicated pattern. The acid waters joined the Run at A, flowed on the surface for 800 feet, disappeared underground for 1800 or more, emerged at 2E and vicinity to flow for another 800 feet on the surface, only to again go underground at 2D, and finally reappeared at 1E to stay above ground to its mouth.

The section of stream above 2D is especially interesting, since it carried plant waste without interruption for 38 months, as already mentioned. It gives the widest and deepest measurements to be found. The deepest measurement found was 8 ft. 4 in. by 8 ft. 4 in. in width, although 6½ ft. in depth by 9½ ft. in width was more nearly typical.

The latest chapter to date in the evolution of Jenny Lind Run occurred in midsummer of 1944, and was perhaps the most spectacular of

[1] It was this second swallow-hole that focused attention on the activity of the stream. Between the two swallow-holes there is a railroad trestle across the gorge. Fear that solution had undermined the foundations of this high trestle caused it to be abandoned.

all. The first step was a large cave-in 225 feet below the outfall (A). At this point a small ledge of limestone had been exposed when the channel was artificially lengthened. The exposure is scarcely 12 feet long and originally seems to have been about 2 feet high. It made a part of the east bank of the channel way, although the channel proper seems to have been either clay or clay-covered.

The acid waters working on this limestone ledge on the east bank dissolved a channel beneath the stream so that when the cave-in occurred it was on the west bank. Remnants of this pseudo-natural bridge can still be seen. The cave-in is now large, due to repeated collapse of its roof. It measures 45 feet at its widest by 15½ ft. depth, of which depth 12½ feet is in limestone. A further feature of this cave-in is a tile-lined culvert 75 feet downstream (300 feet below outfall) that held the stream to the artificially established grade. This culvert would also tend to inhibit any scour, had such tendency been present. Between cave-in and outfall a conspicuous post-cave-in feature is a falls 8 feet high over hard-packed stratified clay. While the original land form cannot be determined, this packed clay is inferred to be the bottom of an old sink-hole.

Following the cave-in (4D on map) a new spring appeared on a tributary (3E on map). Thus a radically different pattern of underground courses can be inferred, for though the entire flow of the Run disappeared at 4D it reappeared at several places (2E, 2E[1]), the swamp between, and at 3E. This condition held until the close of operation, October 1945—fifteen months.

The opening 3E is a cave, originally mapped as the source of an intermittent stream. The opening had been closed by a concrete wall extending to within a few inches of the roof. This wall was not breached by the acid waters, but the limestone below was dissolved, making a U-shaped cut 56 inches deep by 48 inches wide.

Measurements were made approximately every .1 mile from source to mouth of this new tributary on depth and width of solution. At the source hydraulic churning had deepened the cut slightly, immediately under the concrete wall; clear of obstruction the solution cut was 48 by 48 inches. This gave a transverse lineal measure—side, bottom, side—of 12 lineal feet. This lineal measure seemed to be a rather constant thing for the whole course of the stream. The least lineal measure found was 10 ft. 6 in. and this increased to 11 ft. 10 in. twenty feet upstream.

This more or less constant lineal measure did not, however, reflect a constant ratio of depth to width. For example, near the mouth trenching was but 18 inches deep and the width was 8 feet. Midway of the course, trenching was 3 ft. in depth and 5 ft. in width.

Probably this reflects the lessening acidity of the waters.

Tributary Changes

The accompanying map shows a number of intermittent tributaries entering Jenny Lind Run. These were dry when visited by the writer. There had been some concentration of flow, due to ditching around powder works buildings, in a few of the streams. This did not noticeably affect

the streams, since those not connected with industrial drainage show essentially the same changes as those that are.

The rapid deepening of Jenny Lind Run might be expected to cause hanging valley tributaries, but such is not always the case. Indeed, the first tributary below the outfall enters the Run *at grade*. This tributary is only 1100 feet from the point where acid poured into the Run. Though originally mapped as a dry valley, there is some intermittent flow due to ditching and concentration of flow by a highway culvert. Weathered and broken stone has been removed for 25 feet and deep channeling of bedrock is observable for nearly 100 yards upstream.

The eastward-swinging stream above 2E, mapped as the head of the Run, has cut back 2 feet into the limestone and has removed all loose material for 33 yards above its mouth.

A very short tributary, just above point 1E, cascades into Jenny Lind. This tributary on the steeper part of the slope, is on bedrock, and is little deepened.

The westernmost tributary is uneffected. It empties into New Jenny Lind Run $\frac{7}{10}$ mile below 3E. This part of the Jenny Lind course is clay-floored. Hence, there are no changes in main stream or tributary due to solution.

Solution Patterns

King described the corrosion pattern in a semi-arid region as "shallow, flat-bottomed, sub-circular basins, with their steep and sometimes overhanging, fretted margins".[2] This pattern is not found in Jenny Lind Run but a quite different one. The difference is assumed to be the result of continuous abundant water in the stream.

The bedrock of the now dry stream bed has been etched into random, shallow, saucer-shaped depressions a few inches across, the whole giving a sort of dappled effect. There are no well-defined ripples. The patern is conspicuously interrupted by numerous fossils. These are sufficiently silicified to resist solution and so stand above the surface beautifully clean and free of gangue. Indeed, frequently they are on delicate pedestals that break at the touch of the hand.

The limestone parts of the stream bed are always rough. Clay portions, on the other hand, are smooth or marked by shallow grooves parallel with the stream sides.

Conclusion

Since the concentration of acid in Jenny Lind Run during the operation of the Powder Plant was so greatly in excess of any found in nature, the effects here described cannot be generally encountered. Nevertheless, it is believed that the solution accomplished by the high acid concentrations is, at least in part, comparible to results accomplished by nature in a vastly longer time with waters of lesser acid content.

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[2] King, P. B. Corrosion and Corrasion on Barton Creek, Austin Texas. *Jour. Geol.* v. XXXV #7 Oct.-Nov. 1927, p. 635.

HISTORY OF SCIENCE

Chairman: C. A. BEHRENS, Purdue University

Dr. S. S. Visher, Indiana University, was elected chairman of the section for 1948.

ABSTRACTS

Starred scientists born or trained in Indiana. S. S. VISHER, Indiana University.—Indiana was the native state of 81 scientists starred in the biographical directory "American Men of Science" as especially distinguished in research. Each of the 12 sciences in which starring has been done has had 2 or more representatives born in Indiana. For seven sciences, Indiana surpassed more than three-fourths of the 48 states in the yield of starred scientists per million of population at about the date of their birth. Considerable evidence, summarized in the paper, indicates that personal encouragement by enthusiastic, stimulating teachers was an important influence in the output of subsequently starred scientists. For example, 13 of the 19 zoologists were students of David Starr Jordan or of men started by him. In addition, several of Dr. Jordan's students were starred in other sciences. Of the 16 botanists, about 10 were students of John Merle Coulter or of students of his.

Botanist at Purdue University. C. L. PORTER, Purdue University.—A discussion was given of the lives and works of Botanists who are no longer associated with the various Departments of Botany at Purdue. Many are now dead, others are associated with other institutions, still others have retired to private life continuing their hobby—a love of plants. Some of these Botanists became world famous as teachers and investigators. Some have been the subject of voluminous biographies, while others are so little known as to become almost legendary.

The first ten years of the Purdue University School of Pharmacy. Sister CLARA FRANCIS and CHARLES O. LEE, Purdue University.—The opening of the School of Pharmacy in 1884 was an educational adventure that has served the state well. Dr. J. N. Hurty of Board of Health fame was the first lecturer in pharmacy at the new school. The support and interest of a few far seeing pharmacists and the newly organized Indiana Pharmaceutical Association contributed much to the state's experiment in pharmaceutical education. The first class graduated from the two year course in 1886. Mr. E. G. Eberhardt, Eli Lilly and Co., retired, is the only surviving member of the first class.

Sociological and economic factors in Darwinism. WILLIAM J. TINKLE, Taylor University.—The theory of evolution of which Darwinism was the spear head, was part of the protest against medieval doctrines which were held by the nobility and clergy. The fifty years preceding Darwin's "Origin of Species" saw a gradual rise of the middle classes, and the

growth of wealth for the owners of industries. The idea of natural selection gave to economic competition the sanction of natural law. Development of the idea that the universe of mind and matter is guided by natural law was traced in the writing of Descartes, Hobbes, Leibnitz, Berkely, Hume, Voltaire, and Rousseau.

A Revised Chronology for Plant Physiology

RAYMOND E. GIRTON, Purdue University

A chronological chart for plant physiology was first described at the fall meeting of the Indiana Academy of Science four years ago, but was not published. A revision has now been made by the inclusion of additional entries and by the insertion of the nationalities of the scientists listed, where known.

The chronology embraces a period of over 2500 years from the early Greeks to modern times. Subjects dealt with are: General, the cell, photosynthesis, nitrogen metabolism, mineral nutrition, water relations, translocation, respiration, and growth. A reference column of world events is included for the purposes of orienting scientific discoveries in the field of plant physiology with political history.

It is realized that this chronology has many gaps in it. Some of these gaps may be filled as the result of further search into the history of plant physiology. Other gaps undoubtedly represent definite lack of advancement in the subject over certain periods. It will be of considerable interest to extend the chronology to the present, or perhaps to the future-say the year of 1950. Obviously it will be necessary to wait several years before this additional step can be taken.

References

Green, J. R., 1909. A history of botany, 1860-1900. Clarendon Press, Oxford.

Greene, E. L., 1909. Landmarks of botanical history. Smithsonian Institution, Washington.

Locy, W. A., 1925. The growth of biology. H. Holt and Co., New York.

Nordenskiöld, E., 1928. The history of biology (transl. by L. B. Eyre). Knópf, New York and London.

Rabinovitch, E. I., 1945. Photosynthesis and related processes. Interscience Publishers, New York.

Reed, H. S., 1942. A short history of the plant sciences. Chronica Botanica, Co., Waltham, Mass.

Sachs, J. von, 1890. History of botany, 1530-1860, (transl. by H. E. F. Garnsey). Clarendon Press, Oxford.

Stiles, W. and W. Leach, 1936. Respiration in plants (2nd ed.). Methuen and Co., London.

Period	General	Cell	Photosynthesis	Nitrogen Metabolism	Mineral Nutrition	Water Relations	Translocation	Respiration	Growth	World Events
600 BC 1500 AD	*Theophrastus (Greek: 372-287BC)* father of botany	*R. Bacon (English: 1214-94)* le.t drawings of cells	*Aristotle (Greek: 384-322BC)* & *Theophrastus (Greek: 372-287BC)* taught elaborated plant food obtained from the soil	*Vergil (Roman: 70-19BC)* observed beneficial effect of growing legumes before cereals	*Aristotle (Greek: 384-323BC)* Plants obtain food from the soil	*Thales (Greek: 640-546BC)* all things made of water.			*Theophrastus (Greek: 372-287BC)* discussed seasonal periodicity.	*538BC* Fall of Babylon *332BC* Death of Alexander the Great *79AD* Destruction of Pompeii *1000* Lief Erickson to New England *1492* Columbus to America
1500-1600	*Van Helmont (Belgian: 1577-1644)* first recorded experiment in plant physiology		*VanHelmont (Belgian: 1577-1644)* concluded all plant substance from water		*Palissy (French: 1563)* manures & ash increase crops. *VanHelmont (Belgian: 1577-1644)* concluded plant substance not from soil.					*1513* Balboa discovered Pacific Ocean *1588* Spanish Armada defeated
1600-1700	*Malpighi (Italian: 1675)* & *Grew (English: 1682)* fathers of plant anatomy	*Hooke (English: 1665)* described plant cells	*Malpighi (Italian: 1671)* leaves elaborate food from crude sap	*Fuchs (German: 1534)* & *Malpighi (Italian: 1679)* pictured nodules on Vicia faba roots	*Glauber (German: 1650)* KNO_3 promotes plant growth *Woodward (English: 1699)* water culture experiment-believed soil contributes all plant substance		*Malpighi (Italian: 1671)* crude sap moves upward in wood, elaborated sap moves down.	*Malpighi (Italian: 1679)* seeds require air for germination		*1607* Jamestown settled *1620* Pilgrims landed *1636* Harvard founded *1683* Penn's treaty with Indians
1700-1800	*Hales (English: 1727)* "Vegetable Staticks"—father of plant physiology	*Corti (Italian: 1774)* observed protoplasm and protoplasmic streaming	*J. Priestley (English: 1771)* & *Ingenhousz (Dutch: 1779)* mouse bell-jar experiment-plants purify air in light *Senebier (Swiss: 1782)* carbon dioxide from the air decomposed by green leaves			*Hales (English: 1727)* measured root pressure, water flow, lifting power of transpiration, & amts. transpired.	*Hales (English: 1727)* swelling in ringed shoots above ring only.	*Scheele (Swede: 1777)* germinating seeds absorb O_2 and produce CO_2 *Ingenhousz (Dutch: 1779)* all darkened plants, & non-green plants in light, produce CO_2	*Hales (English: 1727)* measured growth of shoots & leaves—apical regions elongate most.	*1707* union of England and Scotland *1776* Declaration of Independence *1787* Constitution drawn up *1789-92* French Revolution
1800-1850		*Brown (English: 1831)* discovered nucleus. *Dujardin (French: 1835)* described protoplasm. *Purkinje (Czech: 1839)* named protoplasm. *Schleiden & Schwann (German: 1839)* cell theory, *Von Mohl (German: 1846)* applied term protoplasm to plant cells.	*De Saussure (Swiss: 1804)* quantitative measurement of gas exchange and water uptake. *Boussingault (French: 1843)* P.Q. = 1.0.		*DeSaussure (Swiss: 1804)* plants absorb soil salts in dilute solution form & in different proportions than they occur in the soil.		*T. A. Knight (English: 1801)* cut stems in dyes indicate that foods from leaves move in inner bark.	*DeSaussure (Swiss: 1804)* O_2 absorbed by germinating seeds = CO_2 evolved—*(1822)* Heat produced by flowers accompanied by O_2 absorption.	*DeSaussure (Swiss: 1804)* seed germination & growth depend on O_2	*1803* Louisiana Purchase *1812* War with England *1819* First steamboat crossed Atlantic *1833* Monroe doctrine *1846* Mexican war
1850-1900		*Schultze (German: 1861)* protoplasm doctrine *Faugl (German: 1879)* discovered plasmodesmata	*Sachs (German: 1862)* starch formed in chloroplasts in photosynthesis, carbohydrates converted to other organic compounds. von *Baeyer (German: 1870)* formaldehyde hypothesis *Timiriazev (Russian: 1896)* starch formation related to chlorophyll absorption spectrum	*Ville (French: 1857)* .*Boussingault (French: 1860)* & *Lawes & Gilbert (English: 1860)* conflicting results on N-fixation. *Schlossing & Müntz (German: 1877)* biological nitrification. *Hellriegel & Wilfarth (German: 1888)* nodulated legumes fix N. *Beijerinck (Dutch: 1888)* isolated nodule bacteria. *Winogradsky (Russian: 1890)* isolated nitrifiers-(1893) Isolated Cloetridium.	*Liebig (German: 1863)* law of the minimum *Sachs (German: 1860) Knopf (German: 1865) Pfeffer (German: 1900)* Water culture formulae.	*Strasburger (German: 1891)* flow in lumen of xylem vessels. *Dixon & Joly (British: 1894)* cohesion theory *Askenasy (1895)* tensile strength of water	*Hartig (German: 1858)* mass flow in sieve tubes. *Sachs (German: 1863)* sugars move by diffusion, proteins by mass flow. *DeVries (Dutch: 1885)* movement by cytoplasmic streaming.	*Pfeffer (German: 1885)* alcohol an intermediate in plant respiration. *Palladin (Russian: 1898)* respiration expressed on protoplasm basis	*Sachs (German: 1874)* growth rhythm, grand period, turgor effects, growth substance suggested. *C. Darwin (English: 1880)* regions of perception & response separate	*1855-7* Atlantic cable *1861-5* Civil War *1898* Spanish-American War *1898* Curies discovered radium
1900-1925	*F. F. Blackman (English: 1905)* limiting factor concept.		*Willstatter (German: 1918)* composition of chlorophyll, hypothesis of photosynthesis *Weevers (Dutch: 1921)* primary sugar in photosynthesis	*Beijerinck (Dutch: 1901)* isolated Azotobacter *Kraus & Kraybill (American: 1918)* carbon-nitrogen relation	*Mazé (French: 1915)* additional essential (trace) elements.	*Browne & Escombe (English: 1900)* diameter law. *Livingston (American: 1906)* atmometer & relative transpiration. *Briggs & Shantz (American: 1912)* wilting coefficient & water requirement. *Maximov (Russian: 1917)* efficiency of transpiration.	*Curtis (American: 1920)* up and down movement in phloem, inorganic solutes move up in phloem.	*Palladin (Russian: 1900)* respiration of starved leaves increased with sugar. *(1908)* chromogen theory. *Kostychev (Russian: 1910)* respiration theory *Dogyer (Dutch: 1915)* heat releases in respiration *Spoehr & McGee (American: 1923)* respiration increased by amino acids	*Boysen-Jensen (Dane: 1910)* conduction of photo-period stimulus. *Paal (1914)* flow of growth harmone. *Garner & Allard (American: 1920)* photoperiodism. *Robertson (1908)* autocatalysis formula	*1903* Wright brothers flight *1909* Peary discovered north pole *1911* Amundsen discovered south pole *1914-18* World War I

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Raymond E. Girton, Purdue University

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References

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Greene, E. L., 1909. Landmarks of botanical history. Smithsonian Institution, Washington.

Locy, W. A., 1925. The growth of biology. H. Holt and Co., New York.

Nordenskiöld, E., 1928. The history of biology (transl. by L. B. Eyre). Knopf, New York and London.

Rabinovitch, E. I., 1945. Photosynthesis and related processes. Interscience Publishers, New York.

Reed, H. S., 1942. A short history of the plant sciences. Chronica Botanica, Co., Waltham, Mass.

Sachs, J. von, 1890. History of botany, 1530-1860, (transl. by H. E. F. Garnsey). Clarendon Press, Oxford.

Stiles, W. and W. Leach, 1936. Respiration in plants (2nd ed.). Methuen and Co., London.

The Historical Development of Medical Bacteriology

C. A. Behrens, Purdue University

If one were to review the early historical developments of medical bacteriology one would readily note that its forerunners were the ancient ideas of superstition. Primitive man regarded disease as an evil spirit to be cajoled by burnt offerings and sacrifices. Symptoms were nothing more than outward manifestations of the activity of the supernatural agents.

Scientific development of medicine begins with the great Greek physician, Hippocrates (460-370 B.C.) who postulated disease as the improper mixture of the four bodily humors; blood, phlegm, yellow and black bile. Because Hippocrates gave the science of medicine its ethical ideals and virtually founded the bedside method, by common consent, he is known as the "Father of Medicine". Hippocrates' teachings were dominant all through the middle ages although supplanted to some extent in the 17th century by the theories of Homeopathy of Samuel Hahnemann (1755-1843). Disease according to this theory "is a spiritual dynamic derangement of a spiritual vital principle". He believed that medicines enhanced in strength by diluting, especially if the dilution was accompanied by shaking and that some drugs gained in potency by pounding. Accordingly, Hahnemann diluted his tinctures fifty times, these were again diluted fifty times and so on even to the thirteenth dilution to which he ascribed the highest potentiality.

The greatest scientist after Hippocrates was Aristotle (384-322 B.C.), the great Greek philosopher and a student of Plato. He introduced the beginnings of zoology, comparative anatomy and embryology to medicine.

Theophrastus of Eresus (372-287 B.C.), the "Father of Botany", a pupil of Aristotle, put the loose plant-lore of the woodmen into a systematic treatise.

Aretaeus, the Cappadocian, a Greek physician who lived at Rome in the second half of the second century A.D., applying the method of Hippocrates, developed clinical medicine and presented us with graphic accurate pictures of such diseases as pneumonia, diabetes, lock-jaw and diphtheria.

Caius Pliny (23-79 A.D.), the natural historian, gave us all that was known in his time of geography, meterology, anthropology, botany, zoology and mineralogy.

The next great figure of this ancient period was Claudius Galen (131-201 A.D.). He was the first experimental physiologist. He also gave us the classic symptoms of inflammation, differentiated pleurisy from pneumonia and described the different forms of tuberculosis.

The outstanding individual after Galen and before Harvey undoubtedly was Andreas Vesalius (1514-64) who established anatomy as a working science.

By far the greatest name of the seventeenth century is that of William Harvey (1578-1657) who in 1626 discovered the circulation of the blood. Following the announcement of this theory of circulation his practice dwindled, the ignorant regarding him as crack-brained. He died, however, an appreciated and honored man.

It was impossible to see the causative agents of infectious diseases without a microscope. The first glimpses into the mysteries of this unknown realm were, of course, simultaneous with the discovery of the microscope. The English monk, Roger Bacon (1214-94), in 1276, appears to have been the first to recognize the peculiar properties of a lens and applied it to the construction of spectacles. It was not, however, until the beginning of the 17th century that the microscope was sufficiently perfected to bring about the existence of microscopic life. The discovery of the compound microscope may be said to have been made by the Italian astronomer, Galilei Galileo (1564-1642), in 1610, although it is probable, that others may have antedated him by a few years.

The earliest one to investigate this invisible world was a Jesuit priest by the name of Athanasius Kircher (1602-80). To him we owe the first clearly presented germ theory of disease, though, the Italian physician Girolamo Fracastor (1483-1553) in 1546, published his ideas on the theory of contagion. In 1660 bubonic plague was raging in London and was common in Europe. Kircher announced that he had seen the organisms in the blood of pest victims. With his very crude 32-power microscope he at best only saw pus or blood cells. The plague germ was not discovered until 1894.

The early compound microscope consisted of a single lens for an objective and of another single lens for an eye-piece. Such an instrument necessarily gave very imperfect results. However, the real value of the microscope as an aid in scientific research dates from the time Charles Chevalier of Paris (1804-59) introduced the method of correcting chromatic aberration in 1825. Antony van Leeuwenhoek (1632-1723), the "Father of Microscopy", who definitely laid the foundations for bacteriology, attracted wide attention by his expertness in lens grinding and did much in developing the microscope into a workable instrument. He made some four hundred biconvex lenses some of which magnified about three hundred diameters. He observed yeast cells in fermenting liquids and swarming organisms in putrid masses. He believed that fermentation and putrefaction was the work of these microorganisms. He was made a fellow in the Royal Society in 1680.

A mechanical genius by the name of Robert Hooke (1635-1763) was another early worker with the microscope. In 1665 he published his famous Micrographia and stimulated much interest in microscopy.

One of the greatest microscopists was Marcello Malpighi (1628-94), known as the founder of histology. He accomplished much by his microscopic investigations of the embryology of the chick and visera in general.

The microscopic world was unknown to the great Swedish botanist, Carolus Linnaeus (1707-78), who systematized the classification of plants and animals. He discovered a disease, anthrax, in Siberian reindeer and said it was caused by a living contagion.

A Viennese physician, Marcus Plenciz (1705-86), carrying on the work of van Leeuwenhoek, in 1762 published his theory in which he stated that every disease had its own particular set or agent. Proof of these facts, however, had to wait over 100 years.

The next great naturalist interested in this field was the Danish zoologist, Otto Műller (1730-84). Because of his masterly pioneering work, "Animalcula infusoria" in which he excellently illustrated many microorganisms, their motility and other unique characteristics, he is referred to as the first scientific microscopist.

Hundreds of years before Christ, artificial immunization was practiced in folk-medicine against smallpox. Lady Mary Wortley Montagu (1680-1762) introduced it in London from Constantinople in 1720. It eventually lead to one of the greatest triumphs in the history of medicine, the successful introduction of preventive inoculation, came toward the end of the eighteenth century. Edward Jenner (1749-1823) observed that dairy maids who had contracted cowpox from milking did not take smallpox. He mentioned this to the renowned Dr. John Hunter (1728-93), who on August 2, 1775 made his famous reply; "I think your solution is just; but why think? Why not try the experiment?" On May 14, 1796, he performed his first vaccination upon a country boy, Thomas Phipps, using material from the arm of the milk-maid, Sarah Nelmes, who was suffering from cowpox. On July 1st, Phipps was inoculated with smallpox virus and the immunization proved successful, for Phipps did not come down with smallpox.

The year 1837 was memorable in many ways. It was the first time in history that an organism was shown to be the cause of disease. Agostino Bassi (1773-1856), an Italian, demonstrated that the disease, known as muscardine affecting silkworms was caused by a fungus and was transmitted from the diseased to the healthy worm. Later, in the same year Charles Cagniard de la Latour (1777-1859) and Theodor Schwann (1810-82) independently, proved that the yeast cell produced alcoholic fermentation. It will be recalled that the renowned chemist, Justus von Liebig (1830-73) bitterly opposed this theory, stating that the so-called cells were by-products of a chemical phenomenon.

Christian Ehrenberg (1795-1876) published his systematic classification of microorganisms in 1838. He was the first to observe spores or eggs possessed by bacteria.

Matthias Schleiden (1804-81) and Schwann in 1836 announced their cellular unit of life theory. This expounds that tissues of all plants and animals are composed of units called cells and according to this theory a life composed of a single cell could not have organs comparable to those found in large multicellular creatures.

In 1842, at the time cholera was raging in Europe, the brilliant anatomist, Jacob Henle (1809-85) formulated rules which were independently stated by Robert Koch in 1881, whereby, the germ theory of disease could be demonstrated.

Ferdinand Cohn (1828-98), one of the founders of bacteriology, classified bacteria accentually the same as Ehrenberg. It was Cohn who discovered and encouraged Robert Koch.

It will be noted that the scientific advancements kept pace with the perfection of the microscope. The vast development along biologic lines at this time was mainly due to the theories of Darwin (1809-82). His "Origin of Species by Means of Natural Selection" was perhaps one of the outstanding pieces of research in the history of science out of which came the sciences of cellular pathology, bacteriology and parasitology.

The advancement of modern medical science is inseparably connected with the name of Rudolf Virchow (1821-92), the founder of cellular pathology. He succeeded Johannes Müller (1801-1858), medical naturalist, under whom he received his training as did Schwann and Henle, as the dominating figure in German medicine.

Aided by the discoveries of Pasteur, Lord Joseph Lister (1827-1912) was able to announce his principles of antiseptic surgery in 1867 which revolutionized surgery. He was not aware, however, of the work of Ignaz Philipp Semmelweiss (1818-65), who in 1846, 21 years previous to Lister's announcement, by the insistence of washing the hands with chlorinated lime before all examinations were made in maternity cases, caused death from infection pertaining to child-birth to fall to one-tenth of that in previous years. Semmelweiss was ahead of his time, was persecuted and died insane. The development of antiseptic surgery was necessarily one of the first triumphs of modern medicine.

The brilliant, adventurous and courageous Louis Pasteur (1822-95), the great French chemist and bacteriologist, is memorable for his work in 1848 on the optical activity of tartaric acid; the overthrowal in 1860-1 of the ancient theory of spontaneous generation; fermentation in 1857; research on anthrax and chicken cholera in 1877 and his preventive vaccination in 1880, particularly of rabies in 1885. His researches are the beginning of modern bacteriology. The Pasteur Institute was founded in Paris in 1888.

His contemporary, the meticulous, ingenious and patient Robert Koch (1843-1910), an obscure country physician, a student of Henle, in 1876 presented his methods of preparing and staining bacterial films. In the same year, he published his classical research on anthrax. In 1882, he announced his discovery of the causative agent of tuberculosis which was responsible for about one-seventh of all deaths. One of the greatest aids to the advancement of bacteriology was the introduction of his gelatin plate method of obtaining pure cultures of microorganisms in 1887. Koch received the Nobel prize in 1905. The establishment of modern practical bacteriology dates from his experiments. Following the announcement of his new isolation technique, bacteriology developed rapidly.

Georg Gaffky (1850-1918), the successor of Robert Koch in Berlin, along with Koch in 1883 found that the "comma bacillus" caused cholera and discovered how it was transmitted. In 1884 he was the first one to cultivate the typhoid bacillus on cultural media.

The beginning of serology and immunology was due mainly to Emil von Behring (1854-1917) and Sibasaburo Kitasato (1852-1931), who in 1890 were the discoverers of antitoxin. Kitasato, also, was the first to cultivate the bacillus of tetanus in 1889. Emile Roux (1853-1933) and Alexander Yersin (1863-1943), in 1888-90 discovered diphtheria toxin.

Roux was the first to use the horse to produce antitoxin on a large scale. Yersin and Kitasato working independently discovered the plague bacillus. in 1894.

Friedrick Loeffler (1852-1915) and Paul Frosch (1860-1928) associates of Koch, in 1892 recognized the filter-passing character of the virus of foot and mouth disease. This was the beginning of searches for the nature of viruses, their peculiarities and immunological and serological reactions and the development of special techniques in dealing with this group of infectious agents. In 1884, Loeffler isolated the diphtheria bacillus and showed its etiological relation to the disease, although, Klebs in the previous year, described the bacillus which bears their names. Loeffler founded the "Centralblatt fűr Bacteriologie" in 1892.

Vaccinotherapy was originated by Metchnikoff, Wright and others. Elie Metchnikoff (1845-1916), a Russian zoologist, succeeded Pasteur as director of the Pasteur Institute in 1895. He formulated the theory of phagocytosis. In 1908, he was awarded the Nobel prize.

Sir Almrott Wright (1861-1946), demonstrated that blood contained substances (opsonins) that prepared bacteria for phagocytic ingestion and originated anti-typhoid vaccination.

In 1902, Charles Richet (1850-1935) and his associates first called attention to the vast subject known as "hypersensitiveness"—anaphylaxis, allergy, or idiosyncrasy, though, observations of this peculiar phenomenon appeared in the literature as early as 1835-37. Richet coined the term anaphylaxis (against protection) for this reaction. He was made Nobel prizeman in 1913.

Bordet and Wasserman introduced serodiagnosis. Jules Bordet (1870-1946), a Belgian, is known for his work on theoretical immunology and with Octave Gengou (1875-19-), discovered the phenomenon of complement-fixation. In 1919, the Nobel prize was awarded him. These bacteriologists discovered the causative agent of whooping-cough in 1906, which is known as the Bordet-Gengou bacillus. Bordet in 1898 discovered the phenomenon of hemolysis. August Wassermann (1866-1925), director of experimental therapy and biochemistry of the Koch Institute for Infectious Diseases, in 1906, attained great fame by developing the test for the diagnosis of syphilis which bears his name.

Paul Ehrlich (1845-1915), a Nobel prize Winner in 1908, and his followers, who laid the foundation for chemotherapy against parasitic infections, also pioneered in modern immunology. He presented the "Sidechain" theory of immunity; standardized diphtheria antitoxin and synthesized arsphenamine ("606").

Karl Landsteiner (1868-1946) was born and studied medicine in Vienna. Since 1922, he was associated with the Rockefeller Institute. He is especially known for his work in blood groupings and immunology and naturally, he contributed much in the field of medical bacteriology. He, too, was made a Nobel prizeman in 1930.

And so we can say that although diseases were known hundreds of years before Christ and much notable research has been attained, it, however, required such geniuses as Louis Pasteur and Robert Koch to develop methods whereby one could correlate and associate the micro-

organisms revealed by the microscope to the phenomenon they produced. Thus, the establishment and recognition of bacteriology as a cardinal modern practical science.

MATHEMATICS

Chairman: J. C. Polley, Wabash College

Dr. L. H. Whitcraft, Ball State Teachers College, was elected chairman of the section for 1948.

ABSTRACTS

Pythagorean triangles. John Fundenberg and G. A. Jackson, Huntington College.—In a Euclidean plane an assemblage of points representing Pythagorian triangles was shown to consist of a parabolic lattice set and sets that were multiples of this set. A sub-set contained all primitive triangles. It was demonstrated that this assemblage of points could be located on systems of hyperbolas, circles, and straight lines. The approximate values of certain constants were shown to be obtained by the use of convergent or oscillatory series, of which the members were represented by points included in this assemblage.

The circle used as a base curve in the construction of certain curves studied in Analytic Geometry and Calculus. Florence A. Wirsching, Purdue University.—The curves discussed included the conchoid, the cissoid, the cycloid, the epicycloid, and hypocycloid, the witch of Agnesi, the limacon, and the lemniscate.

Some special sums of cotangents. H. F. S. Jonah, Purdue University.—A method was given for the summing of a certain finite sums of cotangents. The original sums arose in a research project in Electrical Engineering.

Mathematics teacher training in relation to the proper teaching of undergraduate Algebra. A. E. Ross, University of Notre Dame.—A discussion was given of a fundamental approach to the teaching of algebra in college as well as the problem of training teachers to carry out such a program of instruction successfully.

A study of factors related to student progress in mathematics. Paul Irick, Purdue University.—The results of a study made at Purdue University were presented. The study showed the relation between grades in the first two years of college mathematics and such factors as: position in graduating class in high school, average grade in high school mathematics, number of units of high school mathematics, grades on tests given during orientation period.

A mathematical theory of religion. G. H. Graves, Purdue University.—Due to the studies of Whitehead, Russell, Keyser, and others, it is now generally accepted that pure mathematics has no particular subject matter, but is concerned with constructing logical systems on postulates suggested by any field of interest. Religion is a promising field in this connection for in religion we constantly observe conclusions,

decisions, and hence conduct and character, resulting from postulates held as convictions by an individual or by a society. Just as geometry has gained greatly in clearness and in range by a study of its foundations and by the recognition of the existence of incompatible systems which are individually consistent, so it may be expected that different religions can gain in clearness and tolerance by studying their fundamental postulates with a view to eliminating contradictions and non-essentials.

A reduced set of postulates for hyperbolic geometry. H. F. DEBAGGIS, University of Notre Dame.—A minimal set of postulates for hyperbolic geometry were presented. Independence examples were given for all the postulates.

The postulates of tri-operational algebra. F. L. BROWN, University of Notre Dame.—A minimal set of postulates for a tri-operational algebra was presented. The independence of the set was shown and a few elementary consequences were derived. (These consequences were among those published by the author in *Reports of a Mathematical Colloquium* Issues 5-6, 7, Notre Dame, Indiana.)

Geometric illustrations of abstract complexes. CHARLES BRUMFIEL, Ball State Teachers College.—Two and three dimensional examples of abstract topological complexes were given. The incidence matrices of an n-complex completely determine its topology. Methods were explained for calculating topological invariants, Betti numbers, and torsion coefficients by means of the incidence matrices.

PHYSICS

Chairman: B. A. HOWLETT, Rose Polytechnic Institute

Dr. J. C. Hendricks, Franklin College, was elected chairman of the section for 1948.

ABSTRACTS

The mass and density distribution in our solar system. D. TER HAAR, Purdue University.—It can be shown that every theory about the origin of the solar system can explain the difference in mass and density between the major (outer) and terrestial (inner) planets, if it starts from a situation where the sun in its present position is surrounded by a gaseous disc as first introduced by Kant. This difference in mass and density is a consequence of the fact that the gas pressure will be higher than the saturated vapor pressure of most inorganic compounds throughout the disc, while the gas will only be supersaturated for organic compounds in the colder (i. e. outer) regions of the disc. It is also possible to explain the difference in density in the series of the terrestial planets as a consequence of their different masses.

Deviations from Ohm's law in Germanium. R. BRAY, Purdue University.—Semiconductors obey Ohm's Law only at relatively weak fields. Above certain critical field strengths, which are different for different semi conductors, the conductivity increases rapidly. This critical field strength may be as high as 10^4—10^5 V/cm in CuO or as low as about 100 V/cm in selenium. Our investigations with germanium samples of resistivity near 1 ohm-cm show in this case a critical field of the order of 100 V/cm. The fields are applied in short pulses, a few microseconds in duration, in order to prevent heating of the samples. Observation of the pulses on the oscilloscope shows that the effect of the electric field is not instantaneous, but of the order of 10^{-7} seconds. For all these semiconductors, an irreversible breakdown occurs at much higher fields. None of the many proposed theories adequately explain all the observations in this field, such as the low fields at which the effects begin, the temperature dependency, the difference between semiconductors, the dependence of conductivity on field strength.

Calculation of resistivity curve for Tin doped Germanium. V. A. JOHNSON, Purdue University.—Lark-Horovitz and Dowell prepared a series of germanium samples with from one to seventeen atomic percent of tin added. These samples were studied by x-ray methods to determine the amount of tin actually taken up in the germanium lattice and the amount of tin remaining free on the grain boundaries. It was found that the bulk of the tin was free. Scanlon and Lark-Horovitz have measured the resistivitis of these samples at temperatures of 295°K and 88°K.

They found that, as the temperature decreases, the resistivities of the various samples decrease, following curves closely parallel to the resistivity curve of pure tin. This behavior is explained by assuming that most of the added tin collects along the grain boundaries as free tin and conducts current in parallel with the germanium portion of the sample. The percentage of free tin may be computed from the resistivity samples. The calculated values are found to be in fairly good agreement with the percentages found by x-ray methods.

Photonegative Effects in Germanium Crystals. S. BENZER, Purdue University.—The resistance of a metal-to-germanium point contact is in many cases quite sensitive to illumination, the effect of light usually being an instantaneous increase in current. In some cases, however, as the illumination is maintained, the current actually decreases to a value which may be as low as half the original dark current. When the illumination is removed, the current drops still further and then gradually increases back to the original dark value. The time constants involved in these effects are of the order of minutes, compared with less than 10^{-5} second for the instantaneous photoeffects. Photonegative effects have also been observed in materials other than germanium and are of interest in connection with the theory of the rectifying contact.

Determination of the dielectric constant of Tellurium. V. A. JOHNSON, Purdue University.—Scanlon and Lark-Horovitz have recently investigated the electrical properties of tellurium. In order to compare their results with semi-conductor theory, it is necesary to know the dielectric constant of tellurium. The value is estimated from optical constants by two different methods. The first method, developed by Herzfeld and Mullaney, uses the classical dispersion formula to express the dielectric constant in terms of the index of refraction and coefficient of extinction. Since tellurium is non-isotopic, there are two sets of such data depending upon whether the single crystal axis is parallel or perpendicular to the plane of incidence. For these cases, the dielectric constant is found as $5.0 \pm .5$ and $2.2 \pm .5$, respectively. Since the tellurium samples used in electrical measurements are composed of many randomly oriented single crystals, the dielectric constant may be taken as an average, $3.6 \pm .5$. The second method uses reflectivity data for various wave lengths in the infra-red and is based upon the electromagnetic theory of light in a conducting medium. This method yields a dielectric constant of 3.9. The agreement between values obtained by the two methods is satisfactory.

The isomeric pair In^{112}. H. L. BRADT and D. J. TENDAM, Purdue University.—The 23 minute period of In^{112} is followed by negative and positive electrons, In- and Cd- X-rays, and the conversion electrons of a highly converted 0.16 Mev gamma-ray. Since a large fraction of the X-rays are In-X-rays, the observed conversion electrons must be emitted in an isomeric transition in In^{112}, the period of the upper level being 23 minutes. Decay curves of In^{112}, produced by Ag (α, n) and In $(n, 2n)$ and In (γ, n) reactions show that the negative and positive electron activity follows the 23 minute period only after a certain time. This growth curve,

first observed by R. N. Smith in this laboratory, shows that a 9 minute activity grows from the 23 minute activity; the effect is greatest in the decay of In^{112} produced by (γ, n) and $(n, 2n)$ reactions with In^{113}, smaller in that produced by the Ag^{109} (α, n) reaction, and not noticeable in In^{112} from the Cd^{111} (d, n) reaction. The excitation energy and the lifetime of the metastable level place the In^{112} isomeric transition in the $l=4$ group. Measured values of the conversion probability and the absolute intensity of the In-K-X-rays are in good agreement with the values calculated for electric 24-pole radiation.

The relative yields of the $(\alpha, 2n)$ and (α, n) reactions for bombardment of Rh^{103} with 15-20 mev alpha-particles. D. J. TENDAM and H. L. BRADT, Purdue University.—In order to test the statistical theory of nuclear reactions of V. F. Weisskopf, the relative probability of emission of one to two neutrons from the compound nucleus, which is formed by the bombardment of Rh^{103} with alpha-particles, was measured as a function of the energy of the bombarding particle. Emission of one neutron from the compound nucleus, that is, the Rh^{103} (α, n) Ag^{106} reaction, leads to the well known silver isotope Ag^{106} either in its ground state, which decays with a half-life of 25 minutes by $\beta\pm$ emission, or in its isomeric metastable state, which decays by K-capture with a half-life of 8.2 days. Emission of two neutrons, that is, the Rh^{103} $(\alpha, 2n)$ Ag^{105} reaction, leads to the silver isotope Ag^{105}, to which heretofor a period of 45 days has been assigned only tentatively. From its excitation curve it is clear that the 45 day period is the product of an $(\alpha, 2n)$ reaction and hence can be assigned definitely to Ag^{105}. The threshold for the Rh^{103} $(\alpha, 2n)$ Ag^{105} reaction is 16 ± 0.5 Mev. The curve for the yield ratio of the competing $(\alpha, 2n)$ and (α, n) reactions are in agreement with the results of the statistical theory of nuclear reactions.

A detailed study of the beta-ray spectra of Cu^{64}. C. SHARP COOK and LAWRENCE M. LANGER, Indiana University.—A large precision semi circular type nuclear spectrometer has been constructed. This instrument is different from most semi circular type spectrometers in that it employs an inhomogenous magnetic field which produces higher order focusing in a plane. This gives the instrument much higher resolution than has been obtainable in the past. Because of its large size (radius of curvature is 40 cm.) the instrument is completely free from scattering. Both the negatron and positron spectra of Cu^{64} have been studied under optimum conditions. These measurements indicate considerable deviation from the Fermi theory of beta decay at low energies.

Radiations of Sc^{46}, Au^{198}, and W^{187}. CHARLES L. PEACOCK, Indiana University.—The decays of Sc^{46}, Au^{198}, and W^{187} have been studied in a small 180° type of beta ray spectrometer in which use was made of the fringing field to increase resolution. The Sc^{46} has been found to emit two groups of beta rays of maximum energies .36 and 1.49 Mev and two gamma rays of .88 and 1.12 Mev. The Au^{197} emits a beta ray of .97 Mev and a gamma of .41 Mev. The W^{187} emits two beta rays of .63 and 1.33 Mev and two gammas of .69 and .49 Mev.

The Use of High Speed Motion Pictures in Ordnance Research

James E. Brock, Purdue University

There have been many applications of high speed photography to research in the physical sciences. It is the intention here to discuss the application of the Western Electric 8 mm. Fastax Camera to ordnance research in small arms at Purdue University. For a detailed description of the camera, reference is made to Bulletin No. 1079, Western Electric Company, New York, New York.

Because of its unique construction, pictures can be made with this camera at speeds up to 8000 frames per second. Eastman 16mm. cine kodak high speed super XX panchromatic safety film has been used for all the pictures in these experiments. Pictures are taken on each half of the film and after development the film is split to give two 8 mm. films for projection.

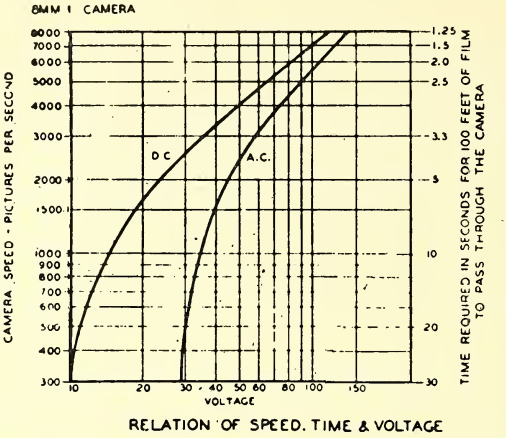
The camera at Purdue University has been used only in connection with mechanism studies related to machine guns. Pictures were usually taken inside the firing ranges and artificial lighting has been necessary. Usually the elements of the guns selected for study were small and consequently the area to be covered in any picture was not great. Lighting for the pictures has been possible with 150 watt projector spot lights operated at 175-200 volts. A small step-up transformer was used to operate the lights from the 110 volt service line at the ranges. One of the lights operated at 175 volts will illuminate an area of about 4 inches diameter with sufficient intensity for pictures at 3000 frames per second if the camera is less than 6 feet from the object. Obviously, for greater distances or higher speeds the lighting must be increased. Projector flood lights and photo flood lamps have been used to supplement the spot lights, especially for background lighting.

The 150 watt PAR/SP 38 projector spot used for the experiments are rated at 120 volts. When operated at 175-200 volts the energy radiated from the spot light is increased considerably, but the efficiency of the light decreases sharply with time, and it has been found advisable to discard them after they have been in use about 15 minutes. No auxiliary reflectors are needed since the lights have a self-contained reflector. Thse lamps were chosen for the experiments because they were readily available, were relatively inexpensive, and required a minimum of auxiliary equipment to adapt them for the work.

The dark oxide-coated finish on all guns and gun parts adds greatly to the difficulties of photographing them when they are in motion. Painting or silver-plating the parts reduces light absorption and increases contrast and detail in the pictures.

The speed of the camera was controlled by means of a 115 volt variabel transformer (Powerstat type 1126, Superior Electric Company, Bristol, Conn.). The most useful speeds for the work have been 2000-3000

frames per second. Since the camera starts from rest, about 30-40 feet of film must run through the camera before full speed is attained. Figure 1[1] shows the relation between applied voltage and the number of pictures



RELATION OF SPEED, TIME & VOLTAGE

Fig. 1. Relation between applied voltage and the number of pictures per second.

per second. Another method for determining the speed is possible with a special timing unit which marks the film at regular intervals. This unit consists of a small argon glow lamp mounted inside the camera as shown in Figure 2[1]. Light from this lamp passes through a minimum for each cycle of alternating voltage. The timing marks appear, therefore,

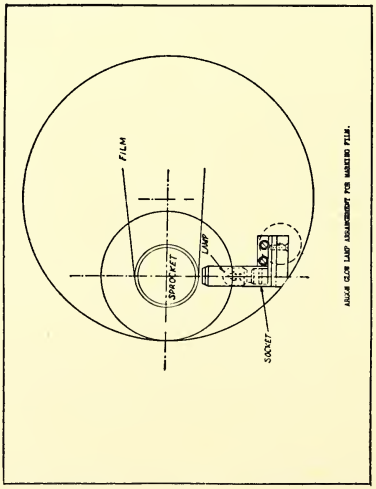


Fig. 2. Arrangement for mounting the Argon glow lamp in the camera.

[1] Courtesy of Western Electric Company.

as alternate bright and dark streaks about 1 mm. wide along the edge of the film and are situated so that they do not interfere with the picture. When the lamp is excited from the 110 volt, 60 cycle, lighting circuit the alternate marks are 1/120 second apart.

Figure 3 shows an arrangement for taking high speed motion pictures of the gun barrel vibrations. In this picture the camera is about 5 feet from the gun. A scale (not visible in the photograph) is mounted on the board to measure the barrel displacement. One of the spot lights illuminates the barrel and the other lights were arranged to illuminate the scale and reduce the shadow.

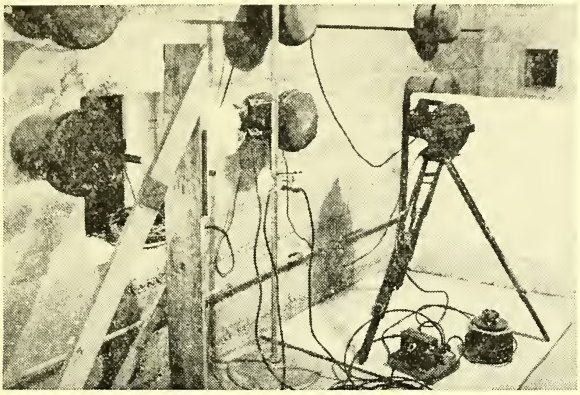


Fig. 3. Arrangement for taking high speed motion pictures of gun barrel vibrations.

A complete list of the studies made with the camera would be too tedious for this paper. A partial list would include the action of such parts as firing pins, cocking levers, ejector units, recoil springs, and the motion of belted cartridges into the feedway of the guns. Pictures of mechanisms taken at very high speeds and then projected at relatively very low speeds is one of the best methods known for studying the characteristic motions of the parts.

PSYCHOLOGY

Chairman: ALMA LONG, Purdue University

Dr. Douglas G. Ellson, Indiana University, was elected chairman of the section for 1948.

ABSTRACTS

Pseudo-psychological beliefs of high school pupils. T. L. ENGLE, Indiana University.—A true-false test of 32 items was administered at the beginning and again at the end of the spring 1947 semester to a group of high school students attending four Indiana high schools. The pupils were enrolled in courses in psychology or in courses containing a large amount of psychological material. Analysis of the responses to each question at the beginning and end of the semester revealed statistically significant improvement. However, there was still a discouragingly high percentage of pupils unwilling to give up beliefs in women's intuition, instinctive love, etc.

Scaling and factorial design in opinion poll analysis. N. L. GAGE, Purdue University.—Most previous attempts to ascertain whether significant differences in attitudes or opinions exist, among groups of individuals classified according to various personal data, have been inconclusive because of their failure to control concomitant variables. Previous attempts at solution of this problem have been made by Crespi and Rugg, Williams and Mosteller, Samelson, Greenwood, and others. The present approach has two components: first, the scaling or quantification of opinion poll responses by means of factor analysis, or its variant, scale analysis; second, the application of factorially designed analysis of variance. The application of this approach to actual data obtained with the Purdue Opinion Poll for Young People was described. Six dichotomous personal data factors were used: grade in school, religion, urban-rural residence, political party preference, economic status, and sex. The superior interpretability of the results of the analysis of variance by factorial design was pointed out. The entire report will be published as No. 61, Studies in Higher Education, Purdue University.

Comparison of paper-and-pencil method and the radio method of polling public opinion. MARJORIE WILLIAMSON, Purdue University.—The objective of the study was to determine whether or not the methods of polling public opinion by the paper-and-pencil anonymous classroom technique or by the radio method differ in a statistically significant fashion. High correlations between opinions indicate that the opinions of students polled by one method can very well be predicted by the second method. Differences between the two techniques lie in the amount of

uncertainty elicited. The paper-and-pencil method elicits a significantly greater amount of uncertainty than does the radio technique.

Relation of benefits of distribution of effort to learning difficulty of a task. R. W. BRUCE, Wabash College.—This study represents an effort to observe the relation of benefits of distributed effort to difficulty of the material to be learned. Fifty-four subjects were divided into two groups. The first group was given 30 seconds in which to study a list of ten words. The same group was then given 3 intervals of 10 seconds separated by rest intervals of 10 seconds. This whole procedure was then repeated with lists of 20 words. Group two was given the same series of tasks, except that the sequence was exactly reversed. The amount learned by each group on each test was immediately measured by the method of retained members. In every case the subjects benefited by the distribution of effort. The greatest gain was shown on the more difficult task.

Observations on human behavior in experimental semistarvation. JOSEPH C. FRANKLIN, Purdue University, BURTRUM C. SCHIELE, JOSEF BROZEK, and ANCEL KEYS, University of Minnesota.—Observations were reported on behavioral changes which occurred in 36 volunteer subjects during a semistarvation-rehabilitation experiment. Six months of semistarvation produced marked deterioration and adaptive changes in all subjects. The physiological responses to undernutrition included such changes as decrease in the pulse and basal metabolic rate. The personality changes were "psychoneurotic" in type and although not grossly pathological, rendered the subjects increasingly ineffective in their daily living. Marked individual differences were present in both the degree of overall deterioration shown in starvation and in the rate of recovery during the period of rehabilitation. Return to normal was unexpectedly slow and in general paralleled the levels of caloric intake.

Action potentials during a tracking response. DOUGLAS G. ELLISON and HARRIS HALL, Indiana University.—Stetson has identified two types of movement: "moving fixations" in which the movement is relatively slow and produced by a change in the balance of opposed muscle contractions; and "ballistic movements", in which the movement is rapid and the opposed muscles contract successively during acceleration and deceleration phases. Action potentials of biceps and triceps muscles were recorded for six subjects during the performance of a single dimension tracking task controlled primarily with these muscles. The results indicated that the periods of inactivity of either muscle which characterize ballistic movement were not present. The activity levels of the two muscles during tracking were positively correlated in time, but the activity of either muscles separately was not significantly correlated with the movements involved in producing and correcting tracking errors.

Patient as person: Personality projection in paintings by psychotic patients. RICHARD LEDGERWOOD, Purdue University.—Work was described which was conducted during the past two years at the Eastern State Hospital, Williamsburg, Virginia, by staff members of the Department of

Psychology, in the College of William and Mary. The research program undertaken related to accreditation of chromo-plastic projection analysis as a psychodiagnostic projective technique of the so-called expressive type. The brush-tempera medium was employed. Methods developed and principal findings were summarily indicated. The present paper was devoted largely to characterization of typical cases selected from the total range of clinical material collected with a view to maximum available diversification of diagnostic types.

Habituation in the "Startle Response" as measured by the action potential technique. DONALD W. VAN LIERE, Indiana University.—Photographic studies of reactions to revolver shots show no "habituation" factor. To further test this hypothesis nine relaxed subjects were subjected to five shots from a 32 caliber revolver given at two minute intervals. Action potentials were taken from the upper dorsal surface of both forearms (extensor muscles). Results show that the highest level of activity is reached during the third "tenth" second following the shot. For the five shots there is no significant variation for either right or left hand. A normal resting state is not reached by the end of the seventh second but occurs sometime before two minutes. Previous investigations assumed a normal state was reached in about one and a half seconds.

An experimental study of avoidance behavior. S. L. CAMPBELL, Indiana University.—This paper reported an investigation of the independence of "avoidance" behavior from "escape" behavior, and of factors relevant to "avoidance" conditioning. An automatic shocking-grid device for use with rats was developed for the present study. An escape response was reinforced by withdrawing shock for fifteen seconds. A second group of rats was similarly conditioned, but could also delay shock for fifteen seconds by anticipatory responding. Extinction records of the secondary drive, avoidance response, and escape response will be shown. It is concluded that the effectiveness of avoidance conditioning depends upon: (1) intensity of the unconditioned stimulus; (2) presence of external discriminative stimuli; (3) the operation of delaying the unconditioned stimulus.

A comparison of various manipulative techniques in a tracking test. D. CRAIG, Indiana University.—This report discussed the results of research carried out at Indiana University for the Aero Medical Laboratory, Engineering Division, Air Materiel Command.

Experiments on a suggestion-induced movement response. Z. H. LURIA, Indiana University.—Subjects were seated in total darkness for a 15 minute period during which no experimental stimuli were presented. They were instructed to report anything observed. One group was told to report the extent and direction in which they were moved. In the suggestions to the second group no suggestion of movement was given. Both groups reported movement although no movement occurred. The suggestion group reported the occurance of movement significantly more frequently than did the other group. This latter group was retested with

instructions incorporating the suggestion of movement and the number of reports of movement increased significantly. It is concluded that when visual cues are eliminated, suggestion readily influences the subjects' report of stimulation, and that postural cues are surprisingly ineffective as checks on body position.

Arithmetic readiness at the kindergarten level. ROBERT H. KOENKER, Ball State Teachers College.—The problem of this study was to discover the value, if any, of a rich arithmetic readiness program at the kindergarten level. Four groups of children were used. In the fall of the year the children were administered an intelligence test and an individual arithmetic readiness test. During the school year the control groups were given the regular kindergarten program. The experimental groups were given the regular program plus a rich arithmetic readiness program. In the spring the children were retested in arithmetic readiness and 27 children from the experimental groups were matched with 27 children from the control groups. By statistical analysis it was found that the children in the experimental groups gained significantly more than the children in the control groups.

ZOOLOGY

Chairman. A. E. Reynolds, DePauw University

Rev. John W. Baechle, C.P.P.S., St. Joseph's College was elected chairman of the section for 1948.

ABSTRACTS

Observations on the behavior of nesting turkey vultures. Howard H. Vogel, Jr., Wabash College.—The nest of a turkey vulture was located in a hollow sycamore tree near Crawfordsville in late May, 1947. When discovered, an adult bird was brooding two newly hatched young. The adult, when disturbed in the nest, feigned death. This behavior was repeated several times on different occasions. Vocalization of the young was a loud, inhalent hissing sound, which increased in intensity and duration with age. Development of the young was studied from May 30 until July 19. Types of social behavior, habits of feeding, development of locomotion, and changes in plumage were observed and described. The paper was illustrated with kodachrome motion pictures and standard lantern slides.

The effect of thiouracil on the development of the chick embryo. W. M. Vernberg, DePauw University—1. Single doses of a 0.5 c.c. of a 0.1% thiouracil solution have no effect on chicken embryos at any stage of development between 36 hours and 9 days. 2. Single doses of 0.5 c.c. of 0.2% solution of thiouracil have no effect on chicken embryos under 96 hours, but cause death and slight hypertrophy of the thyroid gland in embryos injected nine days after incubation. 3. Two injections of 0.5 c.c. of a 0.1% thiouracil solution injected at 18 and 36 hours of incubation, result in marked hyperplasia of the thyroid gland. Identical results were obtained when injections are made at 28 and 48 hours of incubation. 4. Two injections of 0.5 c.c. of a 0.1% solution of thiouracil at 36 and 65 hours of development cause three-fourths of the embryos to die, and cause severe hyperplasia of the thyroid gland in the surviving embryos.

Colored portraits of some common birds. John W. Baechle, C.P.P.S. St. Joseph's College.—A series of about 40 colored portraits of birds was shown, with comments on each. These pictures were made in connection with the banding of 11,000 birds of 80 species during the past six years.

Sex Hormone Response of the Hemipenis of *Eumeces fasciatus* as Reflected by Organ Weight

A. E. Reynolds, DePauw University

I. Introduction

Such studies as have been made on the reproductive physiology of male lizards have demonstrated a number of "target organs" responsive to the sex harmones. Among these are the epididymis and the "sexual segment" of the kidney, which have been shown to undergo, in the normal animal, seasonal and periodic changes correlated with similar changes in the testis (*Anguis fragilis*, Dalcq, 1921; *Lacerta muralis*, Padoa, 1933, Herlant, 1933; *Lacerta agilis*, Regamey, 1935; *Takydromus tachydromoides*, Takewaki and Fukuda, 1935). Further, bilateral castration induced changes in coloration and femoral glands in *L. agilis* (Matthey, 1929), regression in epithelial height and secretory power in both epididymis and "sexual segment" of the kidney in *Takydromus tachydromoides* (Takewaki and Fukuda, 1935), *Lacerta serpa* (Herlant, 1933), *L. muralis* (Padoa, 1933), and *L. agilis* (Regamey, 1935). On the converse side of the picture, Kehl (1938) induced a "sexual segment" condition fully as active as in the male by injection of benzoate of androsterone into the female of *Uromastix acanthinurus* and Noble and Greenberg (1940) found that administration of testosterone propionate maintained the epididymis and vas deferens of *Anolis carolinensis* in the active condition, and developed the "sexual segment" of both sexes. In *Sceloporus*, testosterone propionate produced a marked increase in epididymal tubule diameter and epithelial height (Forbes, 1940, 1941).

The writer, a number of years ago, initiated a program of study on the reproductive physiology of a native American scincoid lizard, *Eumeces fasciatus*, known commonly as the "red-headed skink" (adult male), the "five lined lizard" (adult female), and the "blue-tailed lizard" (immature forms). An initial report (Reynolds, 1943) described the seasonal and cyclic states exhibited by the testis, epidymis, and "sexual segment" of the kidney. Experimental results were also presented showing that the epididymis and "sexual segment" became involute as a result of bilateral castration, and that both could be stimulated by the administration of testosterone propionate. In general, *Eumeces fasciatus* evinced responses consistent with those reported for other lizards as briefly reviewed above.

On *a priori* grounds it would appear that the copulatory sac or hemipenis is another accessory organ vital to the accomplishment of reproduction. As such, its physiological and histological state might logically be expected to parallel that of other accessory reproductive organs by exhibiting seasonal cycles of hypertrophy and involution which may be correlated with seasonal state of the testis. Further, it would be of interest to inquire as to whether or not the hemipenis is under sex

hormone control. Information bearing on these problems is currently at hand in the form of data based on the fresh gross weights of the hemipenial organs concerned, and it is the purpose of this paper to present this information. The anatomical relations of the hemipenis of *Eumeces fasciatus* have been previously described (Reynolds, 1940).

II. Materials and Procedures

At each sacrifice, organs (including hemipenes) desired for study were measured, weighed, or otherwise described either *in situ* or immediately after removal, prior to being dropped into a histological fixative for treatment and subsequent study. Speed was achieved in weighing freshly-removed organs by the use of a magnetically-damped analytical balance (Christian Becker) of the chainomatic type. Body weights were taken on a triple-beam balance; if not anesthetized the animals were contained in a small silk bag with zipper closure, the weight of the bag being deducted from the total to get the weight of the lizard.

Since both animals and hemipenes differ considerably in actual weight, such differences have been smoothed out by the use of means, and by expressing hemipenis weight as a decimal fraction of body weight. Since the decimal fractions are small, they are converted into larger numbers by multiplying by 10^4. Accordingly, the important index values presented in the Tables below are listed as "Weight Ratios" derived by the formula:

$$\text{Weight Ratio (hemipenis)} = \frac{\text{Mean hemipenis weight}}{\text{Mean body weight}} \times 10^4$$

Any given Weight Ratio may be converted into a decimal fraction of body weight by multiplying by 10^{-4}.

A previous paper (Reynolds, 1943) makes brief mention of techniques employed in administering hormones and in operations.

III. Results

A. Males.

1. Normal Seasonal Effects. In Table 1, Part A, are presented the data on 28 normal male lizards studied in a seasonal manner and sampling nine months of the year. A seasonal variation in hemipenis weight is clearly indicated by a glance at the column headed "Hemipenis Weight Ratio". Greatest hemipenis weight occurs in May and June, with the maximum apparently occurring in May. Regression is in progress in July, and the period from October through January is apparently one of involution. Seasonal increase in weight is again in evidence by the month of February.

In Table 1, Part B, the first two entries represent a rearrangement of the data on the 28 normal animals. Here, for purposes of comparison, an arbitrary division has been made such that the months of January, July, October, and November are considered as months of "involution", whereas the months of February, March, April, May, and June, are considered as months of "activity". Thus divided into categories, the weight ratios reveal a difference which further supports the thesis of seasonal variations in weight.

TABLE 1. Hemipenis Weight Ratios of Male Eumeces fasciatus.

	Number of		Mean Weight		Hemipenis Weight Ratio
	Animals	Hemipenes	Hemipenis (mg)	Body gms)	
A. Seasonally, by Month, for Normal Animals					
January ..	2	4	18.20	15.55	11.70
February .	5	10	15.37	6.82	22.50
March	9	18	13.10	6.10	21.50
April	4	8	22.85	14.10	16.20
May	1	2	30.80	7.00	44.00
June	1	2	23.00	6.80	34.00
July	3	6	46.10	30.00	15.40
October ..	2	4	35.60	27.50	12.90
November .	1	2	52.75	48.00	10.99
B. Comparison, by Groups, of Various Categories of Animals					
All Normals at involution	8	16	37.39	28.01	13.35
All Normals at "activity"	20	40	16.99	7.96	21.34
All bilateral castrates .	5	10	15.78	9.48	16.64
All androgen-treated animals ..	6	11	64.50	22.46	28.71

2. Effect of Bilateral Castration. The third entry in Table 1, Part B, consolidates the results on hemipenis weights from five male animals, all sacrificed during "active" months, that had been bilaterally castrate for periods of 27, 47, 184, 459, and 630 days, respectively. It can be seen that the hemipenis weight ratio agrees rather closely with that of normal males at involution.

3. Effect of Androgen Administration. Hemipenial weight data from six male lizards that received injections of testosterone propionate ("Oretone", Schering) are consolidated in the fourth and last entry in Table 1, Part B.

These six animals included three normal males that received the androgen as follows: No. 74, 20 daily injections of 0.1 mg plus a 21st injection of 0.09 mg, totaling 2.09 mg; No. 252, seven injections of 0.1 mg each over 12 days, totaling 0.7 mg; No. 179, nine injections of 0.1 mg each over 21 days, totaling 0.9 mg. The respective individual weight ratios of hemipenes of these three males are: 25.1, 40.0, and 23.1. In addition, the group includes No. 238 which experienced a 31-day period of bilateral castration followed by 8 injections of 0.1 mg of testosterone propionate each over 14 days of time, totaling 0.8 mg; also No. 260 which was bilaterally castrate 6 days followed by an injection period of 15 days during which 8 injections of 0.1 mg each were administered. Respective hemipenis weight ratios are 44.1 and 66.4. The sixth lizard in the group was unilaterally castrate for 11 days after which 10.0 mg of androgen was administered at the rate of 0.5 mg per day for 20 days; individual hemipenis weight ratio is 21.9.

Considering the Androgen-treated group as a whole, it can be seen from the last entry in Table 1 that the hemipenis weight ratio of 28.71 is considerably greater than that of either the normal involute or the castrate group, and exceeds that of the normal group at seasonal activity.

B. Females

A very interesting feature of the female of *Eumeces fasciatus* is the possession of paired rudimentary hemipenes, which although very small in actual size are similar in anatomical relations to those of the male lizard. Since a certain number of females have been included in two experimental groups, data on these affords some information as to the relative responsiveness of this male structure (in the female) to androgens and estrogens. For the sake of comparison, results on the oviducts are included.

In Table 2, Experiment A, the first entry presents results on two normal females (Nos. 110, 245) which received 43 Rat Units of estrogen (Progynon-B, Schering) in 9 injections (9th of 3 RU) over 11 days. The second entry also concerns two normal females: No. 227 received 0.6 mg of testosterone propionate in 6 equal doses over 15 days; No. 258 received 0.8 mg of the androgen in 8 equal doses over 16 days. The third entry under Experiment A relates to No. 217 which was bilaterally ovariectomized for 14 days then injected with testosterone propionate to the extent of 0.8 mg in 8 injections over 16 days, and to female No. 228 which, beginning 31 days after bilateral ovariectomy, received 0.8 mg of androgen in 8 doses over 15 days. The fourth entry consolidates results on three females (Nos. 262, 263, 216) which were bilaterally ovariectomized for periods of 20, 16, and 30 days respectively. The last entry is based on two control females.

In Experiment B, Table 2, the first entry concerns a single normal female (195) that received the 165 I.U. of estradiol benzoate in 11 daily injections of 15 I.U. each. The second entry concerns two normal female lizards (Nos. 75, 87) that received 0.1 mg of androgen daily for 20 days plus a 21st injection of 0.09 mg, making a total of 2.09 mg. The third entry records a female (No. 192) that was unilaterally overiectomized for 31 days prior to sacrifice. The fourth entry in Experiment B

records data on two females (Nos. 196, 200) which were unilaterally ovariectomized 10 and 11 days respectively before initial androgen injections; No. 196 received 18 daily injections of 1.0 mg each while No. 200 received 17 daily injections of 0.5 mg each.

TABLE 2. Weight Ratios of Hemipenes and Oviducts of Female E. fasciatus*.

	No. of Animals	Mean Weight			Weight Ratio	
		Body (gms)	Hemipenis (mg)	Oviduct (mg)	Hemipenis	Oviduct
Experiment A						
Normals plus estrogen	2	6.5	6.3	53.6	9.7	82.5
Normals plus androgen	2	6.85	10.6	53.2	15.5	78.5
Bilaterally ovariectomized plus androgen	2	7.65	14.05	56.4	18.4	73.7
Bilaterally Ovariectomized	3	6.83	2.6	12.9	3.81	18.9
Controls	2	4.75	1.8	10.4	3.8	22.0
Experiment B						
Normals plus estrogen	1	16.00	4.3	91.9	2.69	57.4
Normals plus androgen	2	28.9	31.9	139.6	11.04	48.3
Right unilateral ovariectomy	1	19.0	7.4	22.0	3.89	11.58
Right unilateral ovariectomy plus androgen	2	20.75	14.9	180.95	7.18	87.15
Controls	2	15.4	4.1	9.9	2.66	6.47

* The number of individual organs (hemipenes or oviducts) is, for each category, twice that listed for "No. of animals". Weight Ratios are based on individual organs as units.

Examinations of the hemipenis weight ratios in Table 2 shows a low value (3.81, 3.8, 3.89, 2.66) for those animals of both experiments which received no harmone injections (controls, unilateral and bilateral ovariectomies). In the estrogen-injected series, the two animals of Experiment A evince some increase, while the single animal of Experiment B shows again a low value. The most consistent and greatest increase in hemipenis

weight is exhibited by the androgen-injected females in Experiment A, two of which were normals, while the other two were bilaterally ovariectomized. The four androgen-injected females of Experiment B show weight increases, but not of such amplitude or consistency as those of Experiment A.

For comparative purposes, the oviduct weight ratios, calculated in the same manner as those for the hemipenis, are included in Table 2. It can be readily seen that the oviduct responds to androgen by a weight increase, but it increases to a greater extent under the influence of estrogen. On the other hand, the hemipenis in the same female organisms exhibited maximal response in weight increase to androgen.

IV. Discussion

The general program of which the observations reported herein are a part will eventually produce supplementary and amplifying information which will include in particular microscopic studies on the histological make-up of the hemipenis and the variations occurring therein under different seasonal and experimental circumstances; also to be included are behavior studies as well as greater numbers of both normal seasonal and experimental cases. Organ weight data on the hemipenis have been accumulated deliberately with the view of utilizing them as a guide in the planning of further studies. It is the purpose of this paper to reduce and consolidate these data in order to indicate possible trends and in particular to ascertain to what extent the hemipenis might possibly exhibit a behavior similar to that described above for such other accessory reproductive structures as the epididymis and the "sexual segment" of the kidney.

The seasonal arrangement of quantitative results in Table 1 support the thesis that the hemipenis is a variable organ which manifests an involute period characterized by low weight extending from October through January, followed by weight increase which is evident in February and which continues until a maximum weight is reached in May; in June the hemipenis is still large although some decrease has occurred, while in July definite regression is in progress. When this seasonal and cyclic behavior of the hemipenis is compared with the similar waxing and waning of other reproductive components of *E. fasciatus* such as the epididymis and the "sexual segment" of the kidney, a close parallelism is made manifest. Since such changes have been shown to be definitely correlated with seasonal changes in the testis (Reynolds, 1943), the seasonal changes in the normal hemipenis are thus strongly suggestive of hormonal control mediated through the testis. Experimental support for this view is to be seen in part from the fact that the weight ratios of 10 hemipenes from 5 lizards that were subjected to total testis ablation evinced values very comparable to those of normal animals during the involute period, even though sacrifice occurred during the seasonally active period. Further, in six male animals to which testosterone propionate was administered hemipenis weight increased, the response being such that the weight ratio of the hemipenes exceeded that of normal animals during seasonal activity. Thus in so far as weight is an index,

the evidence from seasonal changes in the normal male and from both castration and hormone injection indicate that the hemipenis of *E. fasciatus* is under testis hormone control.

An additional test of hemipenial sensitivity to androgen is made possible by the fact that the organ exists as a bilateral rudiment in the adult female of *E. fasciatus*. As might be expected of a small non-functional rudiment, these hemipenes are in normal control animals very light in weight (Weight ratios of 2.66 and 3.8 in Table 2). The administration of androgen, however, causes the weight ratio to increase to values from 7.18 to 18.4, representing virtually a four-fold weight enlargement to a level roughly comparable to that of the normal male at seasonal quiescence (cf. Table 1). Ovarian ablation had no effect on the hemipenis weight in the female, the weight ratio remaining essentially the same as in the normal animal. The question as to whether this "male" organ resident within a normal functional female is responsive to estrogens is of interest. Table 2 records only three females that received estrogen, an it can be seen that some increase was exhibited by the hemipenis in two cases, none in the third. In contrast, the oviduct, a typically "female" organ, gave maximal responses to estrogen although androgen also provoked marked weight increases. Taken as a whole, the experimental data based on the females indicate that the hemipenis is primarily responsive to androgen.

V. Summary

1. Expressing hemipenis weight as a decimal fraction of body weight, quantitative results on 28 normal male *Eumeces fasciatus* sampling nine months of the year indicate maximal hemipenial weight during May and June, regression in progress by July, an involute condition from October through January, and thereafter seasonal weight increase which is evident by February.

2. Such seasonal changes in the hemipenis agree quite closely with seasonal variations in the epididymis and "sexual segment" of the kidney, and all may be correlated with the seasonal variations of the testis.

3. Hemipenis weights of five bilaterally castrate lizards are roughly comparable to those of normal males at seasonal involution.

4. Administration of testosterone propionate elicited, in six males, hemipenis weights greater than those of normal males at seasonal hypertrophy.

5. Rudimentary hemipenes in the female of *Eumeces fasciatus* are unaffected by ovariectomy, make a slight response to estrogen, and a more definite response to androgen.

VI. Literature Cited

Dalcq, Albert. 1921. Etude de la spermatogenese chez l'Orvet (Anguis fragilis, Linn.) Arch. de Biol. **31**:347-452.

Forbes, Thomas R. 1940. Some results of the implantation of pellets of testosterone and estrone in adult male lizards (abstract). Anat. Rec. (Suppl) **76**:22.

———— 1941. Observations on the urogenital anatomy of the adult male lizard, Sceloporus, and on the action of implanted pellets of testosterone and of estrone. J. Morph. **68**:31-69.

Herlant, Marc. 1933. Recherches histologiques et experimentales sur les variations cycliques du testicule et des caracteres sexuels chez les reptiles. Arch de Biol. **44**:347-468.

Kehl, R. 1938. Action de l'androsterone sur le "segment sexuel" urinaire de l'Uromastix femelle. Compt. rend. Soc. Biol. **127**:142-144.

Matthey, R. 1929. Caracteres sexuels secondaires du lezard male. Bull. Soc. vaud. Sc. nat. **57**:71-81.

Noble, G. K. and B. Greenberg. 1940. Testosterone propionate, a bisexual hormone in the American chameleon. Proc. Soc. Exp. Biol. Med. **44**:460-462.

Padoa, Emanuelle. 1933. Ricerche sperimentali sui pori femorali e sull' epididimo della lucertola (Lacerta muralis, Laur.) considerati come caratteri sessuali secondari. Arch. Ital. di Anat. e di Emb. **31**:205-252.

Regamey, Jean. 1935. Les caracteres sexuels du lezard (Lacerta agilis, L.) Rev. Suisse de Zool. **42**:88-168.

Reynolds, Albert E. 1940. Some gross anatomical relations of the male urogenital system and other internal organs in Eumeces fasciatus. Proc. Ind. Acad. Sci. **49**:233-242.

———— 1943. The normal seasonal reproductive cycle in the male Eumeces fasciatus together with some observations on the effects of castration and hormone administration. J. Morph. **72**:331-377.

Takewaki, Kiyoshi, and Soichi Fukuda. 1935. Effect of gonadectomy and testicular transplantation on the kidney and epididymis of a lizard, Takydromus tachydromoides. J. Fac. Sci. Tokyo Imperial Univ. **4**:63-76.

A Specific Gravity Method for Determining Hematocrit in Rabbits

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I. Introduction

The procedures and results in this paper are presented to record an adaptation and application of a clinical technique developed during World War II. The extreme desirability of a quick, yet accurate method of making such blood determinations as hematocrit, hemoglobin, and plasma proteins is readily apparent, especially in making appraisal of physiological state with respect to hemorrhage, shock, and other conditions resulting from human participation in modern warfare. A quick and accurate method for determining these blood statistics was developed by Phillips, Van Slyke, et al (1), and used by the armed forces.

The method of Phillips, Van Slyke, et al., is frequently designated the "copper sulphate method" since the crucial operation in the method is to permit drops of whole blood or plasma to fall into solutions of copper sulfate. On entering the sulfate solution the drop becomes encased in a film of copper proteinate which maintains the integrity of the drop up to 20 seconds. On losing initial dropping momentum the drop will either remain at rest, rise, or descend, depending on its specific gravity relative to that of the surrounding copper sulfate solution. Thus the expenditure of only a few drops each of whole blood and plasma suffices for the determination of the specific gravities of each if there is available a series of copper sulfate solutions of finely graded and known specific gravities.

A second foundation of the method consists of the use of certain equations whereby the desired blood statistics can be calculated by use of the determined specific gravity values of whole blood and plasma. The speed and desirability of the method, however, inhere in the fact that calculation by equation is not necessary. Phillips, Van Slyke, et al. have provided a cleverly designed line chart which enables, by use of a straight edge, the direct reading of plasma protein, hematocrit, and hemaglobin, once the specific gravities of whole blood and plasma are known.

The many advantages of the method, as used clinically, at once suggested the possibility of its application to investigations as a research tool. The observations reported herein were planned to apply the method to a laboratory animal and to check the values obtained by the use of the conventional methods. Thus far the method has been applied only to the rabbit as a laboratory form and to the hematocrit as a blood statistic.

For the hematocrit values, Phillips, Van Slyke, et al. utilized an equation formulated by Ashworth and Tiggertt (2), and the derivation can be presented as follows: Let G_B, G_C, and G_P represent the specific

gravities respectively of whole blood, centrifuged cells, and plasma. Let H represent the hematocrit (cc cells per 100 cc whole blood). Then 100 G_B would represent the weight of 100 cc of whole blood. This weight may be equated to the weight of the constituent centrifuged cells plus the weight of the plasma, or

(1) $100G_B = HG_C + (100 - H)G_P$ and (2) $100G_B = HG_C + 100G_P - HG_P$

(3) Then $HG_C - HG_P = 100G_B - 100G_P$ and (4) $H(G_C - G_P) = 100(G_B - G_P)$

(5) Then $$H = \frac{100(G_B - G_P)}{G_C - G_P}$$

(6) Equation (3) may be rearranged: $HG_C = 100G_B - 100G_P + HG_P$

(7) Then $$G_C = \frac{100(G_B - G_P) + HG_P}{H}$$

By measurement of G_B, G_P, and H, both Phillips, Van Slyke, et. al., and Ashworth and Adams (3) arrived at the value 1.097 for G_C, which permits the substitution of this value in equation (5) which then becomes:

(8) $$H = \frac{100(G_B - G_P)}{1.097 - G_P}$$

The line chart of Phillips, Van Slyke, et. al. is based on this equation.

It was the purpose of the study reported herein to apply the copper sulfate method to be determination of the specific gravities of whole blood and plasma from rabbits then to determine the hematocrit from the line chart of Phillips, Van Slyke, et al. and to check this determination by the conventional method of centrifuging whole rabbit blood in Wintrobe Tubes.

II. Material and Procedures

A. Materials

The copper sulfate solutions used in our study consisted of 68 bottles of 4 ounce capacity (approximately 100 cc), with screw caps. This constitutes a "complete set", ranging from specific gravities of 1.008 to 1.075 inclusive by steps of 0.001. Preparation of this series began with 4 pounds of finely pulverized copper sulfate, and necessary large bottles, filtering equipment, volumetric flasks, graduated cylinders, and distilled water. The full bottles were labelled with the specific gravities of their contents, and the entire array placed in four rows in elevated steps such that the full length of each bottle was fully visible.

Blood was drawn with 10 ml syringes fitted with 22 gauge needles; heparin was used as an anticoagulant. A wooden "rabbit holder" was found very useful. Further manipulation of the blood was accomplished by using pipettes made from glass tubing 7 mm in diameter. Each pipette was approximately 20 cm long of which about 15 cm was slimly tapered tip; the opening at the tip was approximately 1 mm in diameter.

B. Procedure

The preparation of the solutions of copper sulfate of graded specific gravities is not difficult and requires little apparatus. The solutions

are all prepared by volumetrically diluting a standard of high specific gravity, the standardization of which is contingent upon the fact that the specific gravity of a saturated solution can be computed if its temperature at the time of the saturation is known. Phillips, Van Slyke, et al. (1) give temperature-specific gravity computation tables and dilution ratios in their monograph. The diluted solutions of copper sulfate of known specific gravity can be made conveniently in 100 ml aliquots and bottled in standard 4 ounce prescription bottles. One hundred gravity determinations can be made in each 100 ml of copper sulfate solution before the specific gravity of the solution is appreciably altered.

A determination of the hematocrit in the rabbit necessitates the use of a heparinized blood specimen. Some experimentation was necessary in the selection of a desirable anticoagulant. Phillips, Van Slyke, et al. (1) suggest the use of a mixture of ammonium oxalate and potassium oxalate with the application of a correction factor to the determined gravities to compensate the alteration of the actual gravity by the oxalate. Rabbit blood specimens oxalated with the ammonium-potassium oxalate mixture would not show consistant gravities and the correction factor was not applicable to the results. Heparin was found to be satisfactory as an anticoagulant. The amount of heparin needed to prevent the coagulation of 2 ml of rabbit blood, which was the average amount drawn for each gravity determination, was very small and the use of a correction factor was not necessary.

In obtaining and testing a blood specimen the following procedure was observed. About one ml of heparin (10 mgm per one ml of water) was drawn into a hypodermic syringe. The syringe was rotated so that the wall of the barrel was "wet" with the solution. The excess heparin was returned to the ampule. This procedure left a film of the solution on the inside of the syringe sufficient to prevent the coagulation of a two or three ml sample. All blood samples were drawn from the marginal ear vein of the rabbit. Immediately following with withdrawal, the syringe was agitated for several minutes to insure uniform and complete heparinization.

The specific gravity of the whole blood was determined by dropping it into the copper sulfate solutions from an average height of 10 mm. Blood dropping from this height hit the copper sulfate with sufficient momentum to break into it as a discrete drop and not spread out as a surface film or plunge to the bottom of the bottle in one rapid movement. As previously mentioned, blood dropped into the copper sulfate will either rise, descend or remain suspended depending upon its specific gravity relative to that of the solution. It was assumed that a drop which remained suspended for 15 to 20 seconds had a specific gravity equivalent to that of the solution into which it was dropped.

After the whole blood gravity was determined the remaining blood sample was divided into two portions. One portion was centrifuged and the plasma thus separated from the formed elements. The plasma was pipetted off, and its specific gravity was determined in the same manner as was that of whole blood.

TABLE 1. Rabbit Hematocrits Based on Whole Blood and Plasma Specific Gravities and the Line Chart, Checked by Centrifuging in Wintrobe Tubes.

Rabbit	Specific Gravities		Hematocrit	
Number	Whole Blood	Plasma	Line Chart	Centrifuge
73	1.049	1.023	35.1	35.0
83	1.046	1.022	32.2	32.2
76	1.051	1.024	37.5	39.7
88	1.050	1.024	35.9	35.9
72	1.051	1.021	39.5	39.5
73	1.052	1.025	37.6	38.0
74	1.054	1.023	42.2	42.0
76	1.050	1.023	36.6	36.6
85	1.054	1.023	42.1	42.0
74	1.049	1.022	36.0	36.2
73	1.049	1.022	36.0	35.0
83	1.046	1.023	31.4	31.4
1	1.047	1.025	31.0	32.0
2	1.044	1.024	27.4	28.0
3	1.052	1.023	39.2	38.0
4	1.052	1.024	38.5	37.5
5	1.047	1.022	33.5	36.0
6	1.055	1.025	42.0	42.0
8	1.052	1.024	38.5	38.0
9	1.043	1.021	29.0	31.0
10	1.050	1.022	37.5	36.0
11	1.049	1.023	35.0	36.0
12	1.045	1.020	32.5	33.0
13	1.048	1.021	36.0	38.0
14	1.051	1.023	38.0	38.0
15	1.050	1.023	36.7	37.0
16	1.049	1.021	36.8	35.0
17	1.043	1.020	30.0	34.0
18	1.052	1.025	38.0	40.0
19	1.055	1.027	40.0	40.0
20	1.048	1.019	37.0	40.0
21	1.046	1.020	34.0	34.0
22	1.053	1.026	38.0	37.0
23	1.050	1.024	36.0	38.0
24	1.054	1.023	42.5	44.0
25	1.049	1.021	37.0	38.0
26	1.054	1.025	41.0	45.0
27	1.045	1.019	33.5	34.0
28	1.055	1.024	42.4	40.0

A line chart devised by Phillips, Van Slyke, et al. (1) was used to compute the hematocrit values. This chart consists of two parallel, vertical lines some distance apart. On one line whole blood gravities are plotted as points. On the other line plasma gravities are similarly plotted. Between these two lines is an oblique line upon which are plotted the hematocrit values. A straight edge connecting the determined whole blood and plasma gravities intersects the oblique line at the hematocrit value.

A Wintrobe tube was filled from the remaining part of the blood specimen. After centrifuging it the hematocrit value was read directly, and this value was used as a criterion for evaluation of the hematocrit by the specific gravity method.

III. Results

Quantitative data on the 39 determinations of the rabbit blood hematocrit that have been made are listed in Table I. A case by case comparison of the values derived by the use of the specific gravities and line chart and those derived from centrifuging shows close agreement in most cases. The range of values of the hematocrit by the two methods are:

By line chart	27.4 to 42.5
By centrifuge	28.0 to 45.0

Strangely enough, the mean hematocrit is identical for the two methods, at a value of 37.0. Lest this be misunderstood, it should be pointed out that there is a *mean difference* between the values by the two methods of 1.13 units. Such indicates that were a given rabbit blood sample tested by both line chart and centrifuge the values would on the average differ by 1.13 units. (ml per 100 ml whole blood). As a further test the coefficient of correlation was calculated by the method of rank differences (rho) with the result that rho equalled 0.9077, this revealing a high correlation between results derived by the two methods.

IV. Conclusions

(1) Mean hematocrit value for rabbit blood in 39 determinations by the centrifuge method was 37.0.

(2) An identical mean (37.0) was obtained in 39 determinations of the hematocrit by the specific gravity method.

(3) The mean difference in hematocrit as determined by the two methods was 1.13.

(4) The coefficient of correlation (as determined by the method of rank differences) between the specific gravity and centrifuge hematocrit values was 0.9077.

V. Literature Cited

(1) Phillips, Robert A., and Donald D. Van Slyke, Vincent P. Dole, Kendall Emerson, Jr., Paul B. Hamilton, and Reginald M. Archibald. Copper Sulfate Method for Measuring Specific Gravities of Whole Blood and Plasma, with Line Charts for Calculating Plasma Proteins, Hemoglobin, and Hemotocrit from Plasma and Whole Blood Gravities. (From the United States Navy Research Unit at the Hospital of the Rockefeller Institute for Medical Research. The work described in this paper was done under a contract

between the Office of Scientific Research and Development and the Hospital of the Rockefeller Institute for Medical Research.)

(2) Ashworth, C. T. and W. D. Tiggertt. 1941. A Simple Rapid Method for Determining Relative Blood Volume Changes by Specific Gravity. Jour. Lab. and Clin. Med. 26:1545-1552.

(3) Ashworth, C. T. and George Adams. 1941. Blood Specific Gravity Studies. Relationship of Specific Gravity of Whole Blood to Specific Gravity of Plasma, Red Cell Count, Hemotocrit, and Hemoglobin as Indicators of Hemoconcentration. Jour. Lab. and Clin. Med. 26:1934-1939

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